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OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 127.

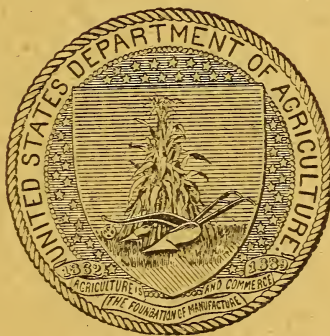
A. C. TRUE, Director.

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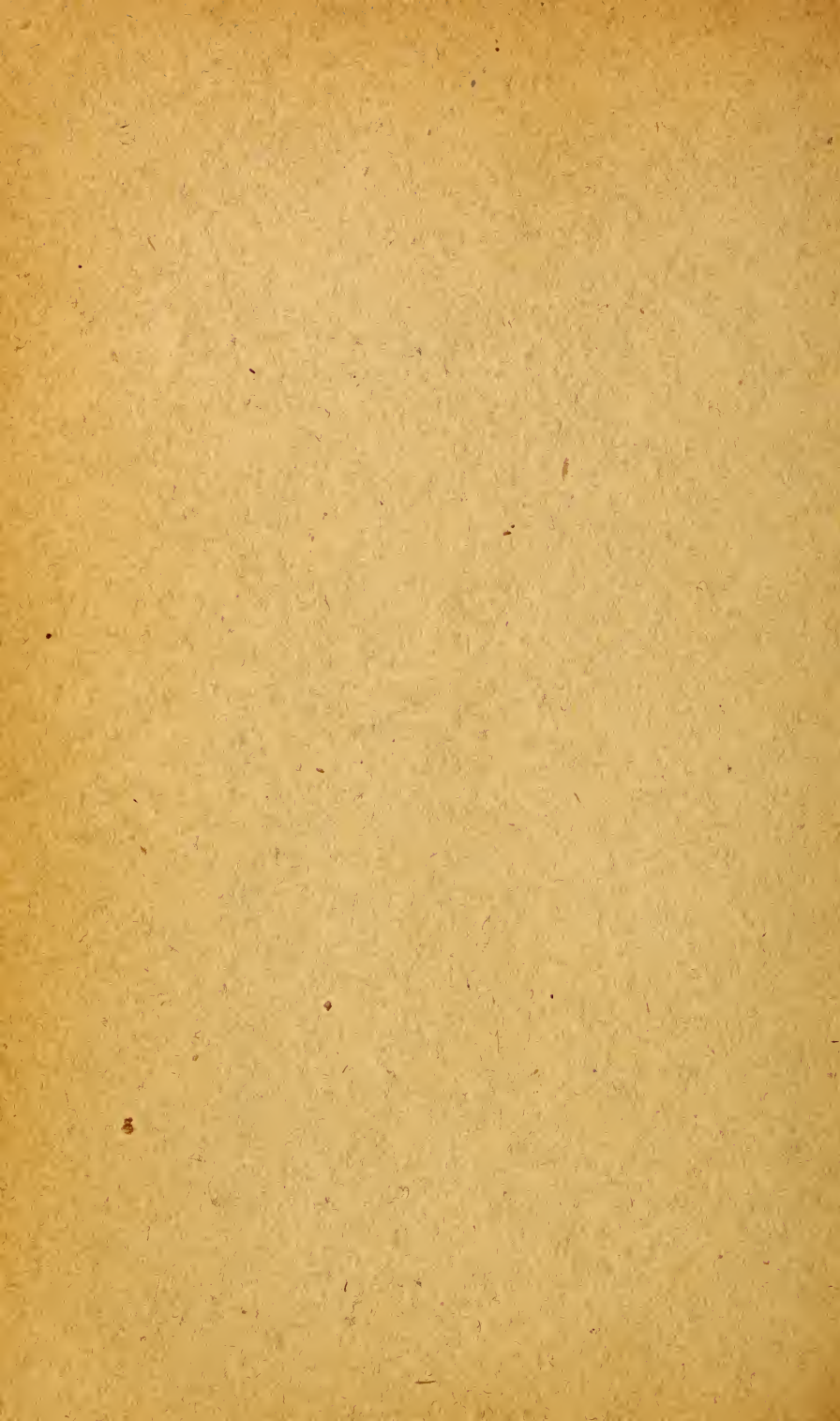
# INSTRUCTION IN AGRONOMY AT SOME AGRICULTURAL COLLEGES.

BY

A. C. TRUE and D. J. CROSBY.



WASHINGTON:  
GOVERNMENT PRINTING OFFICE.  
1903.



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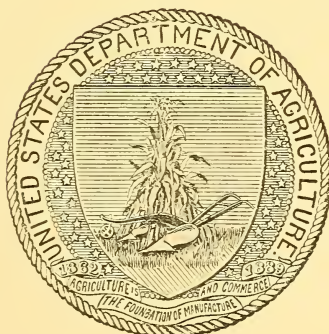
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## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
OFFICE OF EXPERIMENT STATIONS,  
*Washington, D. C., May 18, 1903.*

SIR: I have the honor to transmit herewith a report on courses in agronomy in several agricultural colleges. There is now considerable activity in our agricultural colleges in developing and strengthening the courses of instruction in this division of the science of agriculture. The report has been prepared at the suggestion of the committee on methods of teaching agriculture of the Association of American Agricultural Colleges and Experiment Stations, and is an outcome of the work of that committee. I feel sure that such a comparative presentation of courses actually being given in some of our colleges will aid in the further development and strengthening of this line of work in other institutions, and I therefore recommend the publication of the report as Bulletin 127 of this Office.

The illustrations have been carefully selected from a large number furnished by the colleges, and are intended to show distinctive features of the equipment for instruction in agronomy at the institutions represented in the bulletin.

Respectfully,

A. C. TRUE,  
*Director.*

Hon. JAMES WILSON,  
*Secretary of Agriculture.*



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# INSTRUCTION IN AGRONOMY AT SOME AGRICULTURAL COLLEGES.

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## PURPOSE AND SCOPE OF THIS BULLETIN.

This bulletin is based on the reports of the committee on methods of teaching agriculture of the Association of American Agricultural Colleges and Experiment Stations and on further inquiries made by the Office of Experiment Stations. It is intended to supplement the work of the committee in collating detailed information regarding instruction in agronomy. The status of that work at the time the committee made its sixth report <sup>a</sup> is indicated by the following paragraph from that report :

After consultation with the instructors in agriculture in the different colleges, it has seemed well for your committee to undertake to present in some detail information regarding the courses in agriculture and the facilities for instruction in this subject in our colleges. It is especially desirable to put on record data regarding distinctive features of these courses and the materials for demonstration and illustration already existing in different institutions. Your committee has, therefore, undertaken during the present year to collate such information regarding the course in agronomy. Considerable material has already been accumulated, but some time must elapse before it will be in form for publication. Your committee therefore asks that it may be granted leave to print its report on agronomy in our agricultural colleges, in whole or in part, in the next proceedings of this association, and be given authority to negotiate with the Office of Experiment Stations for the separate publication of its detailed report on this subject.

Authority to publish its detailed report in accordance with the above request was granted the committee, which, however, was not able to prepare the material in time for printing in the proceedings of the association. This Office undertook, therefore, to complete the report and publish it.

Subsequent inquiries on the part of the Office of Experiment Stations by correspondence, by members of the Office force making visits of inspection to the agricultural experiment stations, and by a special officer sent to visit a number of the colleges, showed that while many

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<sup>a</sup> Presented at the convention of the Association of American Agricultural Colleges and Experiment Stations in Washington, D. C., November 12-14, 1901.

of the agricultural colleges have made some progress in differentiating agronomy from the other subdivisions of agriculture, only a few have developed well-balanced courses in agronomy, with laboratory and field practicums in which special forms for scoring different crops and specially devised apparatus are used. It soon became apparent that it would not be feasible to publish within the scope of a Department bulletin detailed information regarding the courses of study in all the agricultural colleges in the United States and, furthermore, that such publication would not at present be desirable because (1) it would include a number of institutions that have not yet been able or have not found it desirable to differentiate agronomy from the general subject of agriculture; and (2) it would include some colleges that are just reorganizing their courses of instruction with reference to the subdivisions of agriculture, including agronomy, and are not now in a position to make a showing commensurate with their facilities for instruction.

It has been decided, therefore, to include in this bulletin (1) a brief review of the work of the committee on methods of teaching agriculture, together with such excerpts from the reports of that committee as have a bearing on the present discussion; and (2) detailed descriptions of courses in agronomy in seven agricultural colleges—six in the United States and one in Europe. The institutions selected include (1) two colleges not connected with universities—Alabama in the South and Michigan in the North; (2) two university colleges having schools of agriculture (agricultural high schools) connected with them—Minnesota and Nebraska; (3) two university colleges in which no provision for preparatory work is made—Illinois and Ohio; and (4) a university college in Germany—the Agricultural Institute of the University of Göttingen.

In the detailed statements regarding the course in agronomy in these institutions the four-year agricultural course has been considered in a general way as to its purpose, requirements for admission, and scope; then attention has been given to agronomy, its position in the four-year course, preparation for it secured by means of previous work in botany and chemistry, its scope and the method of presentation to the students. Under this last head an account has been given of the equipment used, such as buildings, lecture and laboratory rooms, apparatus, collections, special forms, library facilities, and land, and the leading features of this equipment have been illustrated. In the preparation of these detailed statements Prof. J. F. Duggar, of Alabama; Dr. C. G. Hopkins, of Illinois; Prof. J. A. Jeffrey, of Michigan; Prof. W. M. Hays, of Minnesota; Prof. T. L. Lyon, of Nebraska, and Prof. W. D. Gibbs, of Texas (formerly of Ohio), have rendered valuable assistance.

## WORK OF THE COMMITTEE ON METHODS OF TEACHING AGRICULTURE.

The first report of the committee on methods of teaching agriculture<sup>a</sup> pointed out that "one great obstacle to the intelligent discussion of the scheme of agricultural instruction and the methods of agricultural teaching is the lack of a definite nomenclature of the subject," and suggested "for the consideration of the association a tentative scheme for the division of what is commonly designated agriculture in courses of study into several distinct branches or subdivisions, and for giving each of these branches a definite name, as follows:

Agriculture	1. Agronomy, or agriculture (technical).	Climate, soils, fertilizers, and crops—plant production.
	2. Zootechny, or animal industry.	Animal physiology and animal production.
	3. Agrotechny, or agricultural technology.	Agricultural industries, e. g., dairying, sugar making.
	4. Rural engineering, farm mechanics, or farm equipment.	Roads, drains, irrigation systems, farm buildings, etc.
	5. Rural economy or farm management.	General policy of farm management, rural law, agricultural bookkeeping, etc.

In its second report<sup>b</sup> the committee first undertook "to determine the general relation of a course in technical agriculture to the other courses of study which should be connected with this to form a four-year course in an agricultural college," adopting as a working basis the following portion of the report of the committee on entrance requirements, courses of study, and degrees:<sup>c</sup>

In the judgment of your committee, it is not too much to require the equivalent of fifteen hours per week of recitations and lectures, together with ten hours per week of laboratory work, or practicums, including the time devoted to military science and drill. Upon this basis the above-mentioned general studies should be assigned a relative importance, approximately as follows:

	Hours.		Hours.
Algebra.....	75	Modern languages.....	340
Geometry.....	40	Psychology.....	60
Trigonometry.....	40	Ethics or logic.....	40
Physics (class-room work).....	75	Political economy.....	60
Physics (laboratory work).....	75	General history.....	80
Chemistry (class-room work)....	75	Constitutional law.....	50
Chemistry (laboratory work)....	75		
English.....	200	Total.....	1,285

<sup>a</sup>Report presented to the Association of American Agricultural Colleges and Experiment Stations at the convention held in Washington, D. C., November 10-12, 1896. See U. S. Dept. Agr., Office of Experiment Stations Bul. 41, p. 57, and Circ. 32.

<sup>b</sup>See U. S. Dept. Agr., Office of Experiment Stations Bul. 49, p. 29, and Circ. 37.

<sup>c</sup>See U. S. Dept. Agr., Office of Experiment Stations Bul. 41, p. 52.

The total number of hours included in a four-year course, allowing fifteen hours per week for thirty-six weeks, would be 2,140; with ten hours' laboratory work, or practicums, added, 3,600. In general terms, therefore, the foregoing general studies should comprise about two-fifths of the work required for a bachelor's degree.

The committee on methods of teaching agriculture then suggested "additional subjects to be included in a four-year course in agriculture leading to the degree bachelor of science," as follows:

	Hours.
Agriculture .....	486
Horticulture and forestry .....	180
Veterinary science, including anatomy .....	180
Agricultural chemistry, in addition to general requirement .....	180
Botany (including vegetable physiology and pathology) .....	180
Zoology (including entomology) .....	120
Physiology .....	180
Geology .....	120
Meteorology .....	60
Drawing .....	60
Total .....	1,746

Taking up, then, the subject of agriculture, the committee recommended the following allotments of time to its subdivisions:

	Hours.
1. Agronomy, or plant production .....	132
2. Zootechny, or animal industry .....	162
3. Agrotechny, or agricultural technology .....	72
4. Rural engineering, or farm mechanics .....	60
5. Rural economics, or farm management .....	60
Total .....	486

It was also announced that the committee would next take up in detail the topics properly included under the head of "Agronomy," "with a view to presenting a syllabus of a course in that subject which shall show with some fullness the topics to be treated, their relative importance, the time which should be devoted to each, and especially the order of presentation which conforms most closely to sound pedagogical principles." This was done in the third report<sup>a</sup> of the committee, which was divided into three parts, as follows:

- (1) A syllabus defining the limits of a course in agronomy, and stating the topics included in agronomy in the order in which they should be presented to students, i. e., in their logical and pedagogical order.
- (2) A series of lecture or chapter headings showing how the syllabus for agronomy may be applied in preparing a course of lectures or a text-book on this subject, covering ninety-nine class-room hours or periods of sixty minutes each, i. e., three lecture or recitation periods a week.
- (3) A series of subjects for practicums or laboratory exercises to be used in connection with the class-room work in agronomy, and covering the thirty-three remaining hours or periods (equivalent to sixty-six hours of sixty minutes each), assigned to the course in agronomy, i. e., one practicum per week.

<sup>a</sup>See U. S. Dept. Agr., Office of Experiment Stations Bul. 65, p. 79, and Circ. 39.

It has been the object of the committee to make such an outline of this course as can easily be adjusted to the requirements of institutions with different organization and environment. While the syllabus is intended to limit the range of subjects which may properly be included under agronomy, the amount of attention which shall be given to particular topics will vary according to circumstances. The series of chapters and practicums are in a measure intended simply to show a way in which the subject of agronomy may be presented in actual practice. This is especially true of that portion of the course which relates to individual farm crops, to which attention will naturally be given according to their relative importance in different localities.

## SYLLABUS OF COURSE IN AGRONOMY.

DEFINITION .....	{	Theory and practice of the production of farm crops. In agronomy we need to consider the several kinds of plants grown as farm crops under the following subjects:
THE PLANT.....	{	Structure (anatomy). Composition. Physiology. Environment.

We may conveniently begin the study of plant production by considering the general characteristics of the environment of plants as grown in the field.

ENVIRONMENT ----- (General factors.)	{	Light. .	}	Plant food.
		Heat.		
		Moisture -----		
		Air -----		
		Soil ----- {		
		Natural -----		
		With fertilizers		

But environment may be conveniently divided according to position, as follows:

ENVIRONMENT..... (Divided according to position.) (Chapters I-III of lecture out- line page 16.)	1. Above ground. (climate)	{ Light ..... { Heat ..... { Moisture .... { Air .....	Study the relation of each of these factors to plant growth, and also briefly their ef- fects in different com- binations, i. e., differ- ent climates.
	2. Under ground. (soil)	{ Heat ..... { Moisture .... { Air ..... { Earth (soil) .. { Fertilizers ...	Point out that the rela- tion of these factors to plant growth may be most clearly per- ceived by first consid- ering them in their relation to each other.

Soil..... (Chapters IV-XXXI.)	Definition—Nature.			
	Functions.			
	Origin .....	Brief geological outline.		
		Weathering of rocks.		
		Accumulation of organic matter.		
		Transformation of organic matter (nitrification and denitrification, etc.).		
		Additions from atmosphere.		
	Properties .....	Chemical.	Classification of soils, on the basis of their properties.	
		Physical.		Weight .....
				Color .....
				Texture .....
				Capillarity...
				Permeability.
	Temperature.	Absorptive power.		
		Air.		
Moisture .....	Sources.....	Water table.		
	Amounts .....	Hygroscopic moisture.		
		Rainfall.		
	Drainage .....	Irrigation—Methods.		
		Purpose and effects.		
Conservation ..	Methods.			
	Purpose.			
Tillage .....	Purpose and effects.	Methods.		
		Chemical.		
		Physical.		
Fertilizers .....	Methods.	Biological.		
		Definition.		
		Methods and effects of action.		
	Classification.	1. According to constituents—		
		a. Nitrogenous.		
		b. Phosphoric.		
		c. Potassic.		
		d. Other amendments.		
		2. According to form—		
		a. Green manures.		
b. Animal manures.	Farm manures.			
		c. Commercial—classify principal forms.		
(Study first the general theory of fertilizers according to above scheme and then consider in as much detail as may be deemed desirable different kinds of fertilizers, using Schedule A.)				

*Schedule A.*

		<i>Schedule A.</i>	
SOIL—Continued ..... (Chapters IV-XXXI.)	Fertilizers .....	Kinds of fertilizers.	Name.
			Description.
			Properties { Chemical—composition. Physical.
			Place in classifications.
			Sources.
			Uses.
			Preparation, care, and handling.
			Application.
			Effects .... { Chemical. Physical. Biological.
			Economy . . { Extent of production. P e c u n i a r y value.
	Waste and re- novation.	{	Washing.
Transportation by wind and water.			
Leaching.			
Oxidation.			
Cropping—Rotation of crops, systems of farming.			

Having considered in a general way the theory and practice of plant production as related to the structure, physiology, and environment of the plants grown as farm crops, we come next to consider the production of different kinds of crops more in detail.

FARM CROPS ..... (Chapters XX XII- XXXIII.)	Classification ..... (The classification and the kinds of plants to be named under each class will vary according to circumstances.)	Cereals—Wheat, oats.
		Grasses—Timothy, brome grass.
	Legumes—Red clover, alfalfa.	
		Tubers—Potatoes.
		Roots—Mangels.
		Sugar plants—Sugar cane, sugar beets.
		Fibers—Cotton, flax, hemp.
		Stimulants—Tobacco, tea, coffee.
		Medicinal and aromatic plants— Ginseng, mint.
		Miscellaneous—Canaigre, peanuts.
	Methods of improve- ment.	Breeding.
		Selection.

Next study individual farm crops according to the following scheme:

# INDIVIDUAL FARM CROPS.

(Chapters XXXIV-LXI.)  
(The crops to be studied will vary according to locality and other circumstances.)

Name.	
Place in classification.	
Structure.	
Composition.	
Physiology.	
Botanical relations.	
Varieties .....	<div> <div>Classification.</div> <div>Improvement.</div> </div>
Geographical distribution.	
Culture .....	<div> <div>Choice and preparation of soil.</div> <div>Manuring.</div> <div>Seeds (or other parts of plants used for planting)—Selection—amount—treatment.</div> <div>Planting.</div> <div>Cultivating.</div> <div>Place in rotation.</div> </div>
Harvesting.	
Preservation.	
Uses.	
Preparation for use.	
Obstructions to growth, preservation, or use.	<div> <div> <div>Weeds .....</div> <div>Fungi .....</div> <div>Bacteria .....</div> <div>Insects .....</div> <div>Birds .....</div> <div>Quadrupeds ..</div> </div> <div>Means of repression.</div> </div>
Production.	
Marketing.	
History.	

## OUTLINE FOR A COURSE OF LECTURES OR A TEXT-BOOK ON AGRONOMY.

[The lectures are intended to cover 99 hours.]

### Chapter I. General climatic conditions.

- II. Plant food and growth.
- III. Air as a source of plant food.
- IV. The nature, functions, origin, and wasting of soils.
- V. Properties of soils, chemical and physical. Classifications, texture, composition, and kinds of soils.
- VI. Physics of soils as related to plant growth (capillarity, solution, diffusion, and osmosis).
- VII. Soil temperature.
- VIII. Relation of air to soil.
- IX. Soil water.
- X. Irrigation.
- XI. Improvement of soil through drainage.
- XII. Drainage methods.
- XIII. Conservation of soil moisture.
- XIV. Physical effects of tillage.
- XV. Chemical and biological effects of tillage.

## Chapter XVI. Methods of tillage.

## XVII. Methods of tillage.

## XVIII. Fertilizers—Methods and effects of action.

## XIX. Fertilizers—Classification by constituents and form.

## XX. Sources and uses of nitrogen.

## XXI. Sources and uses of phosphoric acid.

## XXII. Sources and uses of potash.

## XXIII. Sources and uses of other amendments.

## XXIV. Practical advice on the use of commercial fertilizers.

## XXV. Humus and green manuring.

## XXVI. Animal manures. General statements.

## XXVII. Manures produced from various animals.

## XXVIII. Care, preservation, and application of manure.

## XXIX. Waste and renovation of soils.

## XXX. Rotation of crops—General statements.

## XXXI. Rotation of crops—Systems of farming.

## XXXII. Farm crops—Classification, production; reasons for choice.

## XXXIII. Improvement of farm crops.

## XXXIV. Wheat—Structure, composition, and varieties.

## XXXV. Wheat—Culture, harvesting, and preservation.

## XXXVI. Wheat—Obstructions to growth, preservation, and use.

## XXXVII. Wheat—Production, marketing, history.

## XXXVIII. Corn.

## XXXIX. Corn.

## XL. Corn.

## XLI. Corn.

## XLII. Rice.

## XLIII. Oats.

## XLIV. Barley and rye.

## XLV. Grasses.

## XLVI. Grasses.

## XLVII. Clovers.

## XLVIII. Pastures.

## XLIX. Silage.

## L. Forage crops.

## LI. Potatoes.

## LII. Potatoes.

## LIII. Root crops—Mangels, beets, turnips.

## LIV. Sugar plants—Sugar beets.

## LV. Sugar plants—Cane, sorghum, etc.

## LVI. Fiber plants—Cotton.

## LVII. Fiber plants—Cotton.

## LVIII. Fiber plants—Flax, hemp, jute, ramie, sisal, etc.

## LIX. Stimulants—Tobacco, tea, coffee.

## LX. Medicinal and aromatic plants.

LXI. Miscellaneous plants—Buckwheat, broom corn, peanuts, hops, canai-  
gre, etc.

[The order of discussion of the different crops will be the same as in the case of wheat. The details to be given for each crop will vary with the importance of the crop in any region.]

**PRACTICUMS OR LABORATORY WORK IN AGRONOMY.**

[The practicums are intended to cover 33 laboratory periods, i. e., 66 hours.]

1. Determination of specific gravity of soils.
2. Determination of volume weight of soils.
3. The power of retaining moisture in the soil in its highest degree of looseness.
4. The power of retaining moisture in the soil when compacted.
5. Rate of percolation of water through soils.
6. Rate of percolation of air through soils.
7. Effect of mulches upon evaporation of water from soils.
8. Behavior of soils toward gases.
9. Capillary attraction in soils.
10. Determination of cohesion in soils.
11. Mechanical analysis of soils.
12. Mechanical analysis of soils.
13. Study of root systems of principal crops.
14. Study of root systems of principal crops.
15. Study of root systems of principal crops.
16. Study of varieties of corn in field.
17. Scoring ears of corn.
18. Study of effect of fertilizers on one or more crops in fall.
19. Study of effect of fertilizers on one or more crops in early spring.
20. Study of effect of fertilizers on one or more crops near harvest.
21. Study of varieties of wheat in sheaf and by sample.
22. Study of varieties of wheat in sheaf and by sample.
23. Study of varieties of wheat in field.
24. Study of varieties of oats or other grain in sheaf and by sample.
25. Study of varieties of oats or other grain in field.
26. Study of varieties of potatoes by sample.
27. Study of varieties of potatoes in field.
28. Study of varieties of grasses and forage crops in field in fall.
29. Study of varieties of grasses and forage crops in field in early spring.
30. Study of varieties of grasses and forage crops near harvest in field.
31. Study of varieties of grasses and forage crops by sample and preparation of abstracts of station experiments on climatic and soil conditions and upon quality and yield.
32. Study of varieties of grasses and forage crops by sample and preparation of abstracts of station experiments on climatic and soil conditions and upon quality and yield.
33. Study of varieties of grasses and forage crops by sample and preparation of abstracts of station experiments on climatic and soil conditions and upon quality and yield.

**DETAILED DESCRIPTION OF COURSES IN AGRONOMY.****ALABAMA POLYTECHNIC INSTITUTE.**

In the Alabama Polytechnic Institute five four-year courses lead to the degree of bachelor of science. These courses are chemistry and agriculture, civil engineering, electrical and mechanical engineering, general course, and pharmacy. Elementary agriculture (breeds of live stock) is taught in the third term of the freshman year in all courses. Agriculture is an elective throughout the sophomore year of the

course in civil engineering, and is required throughout the sophomore and junior years of the course in chemistry and agriculture. This last course, then, may be considered the agricultural course of the Polytechnic Institute. The student in this course devotes about one-fifth of his time to English, history, and economics; about two-fifths to pure science and two-fifths to applied sciences and technical training.

Admission to the four-year courses is by examination or by certificate from schools having approved courses of study. Applicants for admission must be at least 15 years of age, and, if admitted by examination, must be qualified to pass satisfactory examinations in (1) geography and history of the United States; (2) English, including grammar, composition, reading, and English classics; and (3) mathematics, including arithmetic and algebra through quadratic equations. "Those applicants who desire to continue the study of Latin should be qualified to pass a satisfactory examination in Latin grammar and the first two books of Cæsar in addition to the above subjects."

The course in agronomy is given during the second and third terms of the sophomore years. It is preceded by a two-hour course in animal husbandry during the third term of the freshman year, a two-hour course in dairying during the first term of the sophomore year, and a three-hour course of lectures and one laboratory exercise per week in general chemistry during the first term of the sophomore year, and is followed by courses in systematic and structural botany (lectures and laboratory), plant physiology, and agricultural chemistry.

The course in agricultural chemistry is given in the senior year and "consists of lectures on chemistry in its application to agriculture (two per week, during second and third terms), and includes a thorough discussion of the origin, composition, and classification of soils, the composition and growth of plants, the sources of plant food and how obtained, the improvement of soils, the manufacture and use of fertilizers, the chemical principles involved in the rotation of crops, the feeding of live stock, and the various operations carried on by the intelligent and successful agriculturist." During the same periods the students do laboratory work in quantitative analysis six hours per week. The principal reference books used in agricultural chemistry are Johnson's *How Crops Grow and How Crops Feed*, Lupton's *Elementary Principles of Scientific Agriculture*, Johnson and Cameron's *Elements of Agricultural Chemistry*, Storer's *Agriculture*, scientific journals, reports of the United States Department of Agriculture, and the bulletins and reports of the various domestic and foreign agricultural departments and stations. "The laboratories, which are open from 9 a. m. to 5 p. m. during six days in the week, are amply supplied with everything necessary for instruction in chemical manipulation."

Instruction in agronomy is given by the professor of agriculture. "In the second term of the sophomore year the following subjects are

studied: Soils—chemical and physical properties, defects, and means of improvement; the control of water, including means of conserving moisture in times of drought; terracing, underdrainage, and open and hillside ditches; objects and methods of cultivation; agricultural implements; rotation of crops; and improvement of plants by crossing, selection, and culture. The third term of the sophomore year is devoted to the staple crops produced in Alabama, to forage plants adapted to the South, and to plants valuable for the renovation of soils. The more important crops are treated with reference to varieties, soil and fertilizer requirements, methods of planting and cultivating, and uses." In all classes there are mid-term examinations and term-end examinations.

Two hours per week are devoted to lectures, in which the number of students ranges from 10 to 25, and two afternoons per week are given up to farm practice, during which time the classes are divided into sections of from 6 to 9 students. A part of the field work is conducted by the professor of agriculture and a part is in charge of an assistant in agriculture.

In every class the student is encouraged to independent thought on agricultural problems rather than to depend on "rules of thumb," so that he may be prepared to adapt his practice in after years to changed conditions of soil, climate, capital, market, etc. An effort is made to keep before the student the difference between the widely applicable principles on which every rational system of farming rests and the details that vary with changing conditions. The conditions of soil, climate, etc., prevailing in different parts of Alabama are kept constantly in view. As far as limited time allows, attention is directed to agricultural literature now accumulating so rapidly in this and in foreign countries, to the end that in future years the student may know where and how to seek the information that he may need.

Among the reference books and other literature used by students in agronomy are *Soils and Crops of the Farm*, Morrow and Hunt; *Forage Plants*, Shaw; *The Fertility of the Soil*, Roberts; *Corn Culture*, Plumb; *The Physics of Agriculture*, King; other recent American works on agriculture; bulletins of the United States Department of Agriculture and of the experiment stations in the different States, and a number of farm journals.

Lectures in agronomy are given in the main building in a class room provided with chairs and arm rests for 60 students, two sides of the room being occupied by cases for specimens. Three small barns and a gin room serve partly as laboratories for students when engaged in indoor work. Plats on the experiment-station farm showing the effect of fertilizers, methods of culture, etc., and collections of varieties are used as object lessons for students.

The following exhibits will give an idea of the nature and scope of the examinations required in agronomy and of the notes taken by students in the field:

EXHIBIT No. 1.

EXAMINATIONS IN AGRONOMY.

*Examination in beginning agronomy, second term, sophomore year.*

I. (a) In what kind of weather and at what time of year can wetter soils be safely plowed than under other conditions? Explain. (b) Does a clay or a sandy soil contain more moisture when plants begin to wilt? Explain.

II. (a) Discuss the importance or nonimportance of the hygroscopic power of soils. (b) Discuss the practicability or otherwise of determining what fertilizers to apply by an analysis of the soil.

III. Discuss capillarity in the soil (direction of movement, favorable conditions, effect of slight rain after long drought, etc.).

IV. Explain fully the effect of cultivation on the moisture in the different layers of soil.

V. Discuss fully the size and use of the roller and its effects on the soil, and state conditions when it should be used.

VI. Discuss the general direction for ditches, methods of making junctions, and draw cross section illustrating (a) carrying canal, (b) shallow hillside ditches, (c) open drainage ditch.

VII. (a) Discuss grades for open tile drains. (b) Make drawing of homemade level and show how used (c) in making a terrace and (d) in giving a uniform grade to bottom of a ditch.

VIII. Irrigation. (a) Give three commonest sources of water in order of cheapness. (b) What advantages in furrow system over flooding system? (c) What levels would head ditches follow and how would nature of soil influence the grade of the rows?

IX. Discuss fall versus spring plowing in the Gulf States.

X. (a) Give a three-year rotation for cotton farm, showing why the crops should follow in the order stated. (b) Outline a rotation that will put half the land in cotton each year. (c) Construct a five-year rotation for a mixed cotton and stock farm in the central prairie region of Alabama, stating when each crop is planted.

*Examination in agronomy (forage plants), third term, sophomore year.*

I. (a) What advantages has fall sowing of grasses and clovers over spring sowing? (b) Mention three legumes that can not be sown in fall and give best month for sowing each of the three.

II. (a) Compare early versus late cutting of hay. (b) When cut red clover?

III. Give means of distinguishing small grains of oats, wheat, barley, and rye.

IV. Discuss Texas blue grass.

V. Discuss redbud.

VI. Discuss white clover.

VII. Discuss culture and uses of rape plant.

VIII. Give time of sowing, amount of seed, soil requirements, and uses of melilotus.

IX. Velvet beans—uses and culture.

X. Hairy vetch—discuss best mixtures of this with other seed for given conditions.

## EXHIBIT No. 2.

## STUDENTS' FIELD NOTES.

*Notes on varieties of corn.*

Variety.	Number of ears and nubbins per 100 stalks.		Distance from ground to lower ear.			Average distance from ear to ground.	Percentage of ears below horizontal line.	Tip covered by shuck, 5; tip exposed, 0.	Remarks.
	Ears.	Nubbins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.			
Hickory King	48	42	$\left\{ \begin{array}{l} 2 \ 9 \\ 2 \ 6 \\ 2 \ 8 \end{array} \right.$	$\left\{ \begin{array}{l} 3 \ 2 \\ 2 \ 4 \\ 4 \ 2 \end{array} \right.$	$\left\{ \begin{array}{l} 3 \ 2 \\ \text{---} \\ 3 \ 7 \end{array} \right.$	$\left. \right\} 2 \ 9\frac{1}{2}$	63	4	{ Stalks very small and very early.
Shaw .....	90	22	$\left\{ \begin{array}{l} 3 \ 10 \\ 3 \ 6 \\ 4 \ 2 \end{array} \right.$	$\left\{ \begin{array}{l} 5 \ 8 \\ 4 \ 4 \\ 5 \ 9 \end{array} \right.$	$\left\{ \begin{array}{l} 7 \ 5 \\ 5 \ 0 \\ \text{---} \end{array} \right.$	$\left. \right\} 4 \ 9$	25	5	{ Medium light and late; ears above medium in length.
Arnolds .....	62	32	$\left\{ \begin{array}{l} 2 \ 9 \\ 3 \ 9 \\ 3 \ 9 \end{array} \right.$	$\left\{ \begin{array}{l} 4 \ 3 \\ 4 \ 6 \\ 3 \ 0 \end{array} \right.$	$\left\{ \begin{array}{l} 4 \ 6 \\ 5 \ 4 \\ \text{---} \end{array} \right.$	$\left. \right\} 4 \ 0$	28	3.5	{ Late; medium ears.
Experiment Station Yellow.	100	36	$\left\{ \begin{array}{l} 3 \ 3 \\ 3 \ 5 \\ 3 \ 9 \end{array} \right.$	$\left\{ \begin{array}{l} 3 \ 5 \\ 4 \ 4 \\ 4 \ 0 \end{array} \right.$	$\left\{ \begin{array}{l} 3 \ 8 \\ 3 \ 8 \\ 3 \ 7 \end{array} \right.$	$\left. \right\} 3 \ 3\frac{1}{2}$	22	4	{ Above medium height; medium early.
Coeke .....	114	72	$\left\{ \begin{array}{l} 3 \ 7 \\ 4 \ 2 \\ 4 \ 6 \end{array} \right.$	$\left\{ \begin{array}{l} 4 \ 10 \\ 3 \ 8 \\ 4 \ 0 \end{array} \right.$	$\left\{ \begin{array}{l} \text{---} \\ \text{---} \\ \text{---} \end{array} \right.$	$\left. \right\} 4 \ 3$	67	4.5	{ Small stalk, long, slender ears; early.
Mosby .....	124	36	$\left\{ \begin{array}{l} 3 \ 0 \\ 4 \ 4 \\ 4 \ 2 \end{array} \right.$	$\left\{ \begin{array}{l} 3 \ 8 \\ 4 \ 3 \\ 5 \ 0 \end{array} \right.$	$\left\{ \begin{array}{l} \text{---} \\ \text{---} \\ \text{---} \end{array} \right.$	$\left. \right\} 4 \ 4\frac{1}{2}$	81	4	{ Medium or late; prolific and well filled.
Red Cob .....	74	30	$\left\{ \begin{array}{l} 5 \ 7 \\ 5 \ 2 \\ 4 \ 0 \end{array} \right.$	$\left\{ \begin{array}{l} 4 \ 7 \\ 5 \ 6 \\ \text{---} \end{array} \right.$	$\left\{ \begin{array}{l} \text{---} \\ \text{---} \\ \text{---} \end{array} \right.$	$\left. \right\} 5 \ 0$	77	4.5	{ Tall stalks, large ears; late to medium.
Tennessee White.	92	30	$\left\{ \begin{array}{l} 5 \ 0 \\ 6 \ 2 \\ 4 \ 10 \end{array} \right.$	$\left\{ \begin{array}{l} 4 \ 3 \\ 5 \ 0 \\ 5 \ 0 \end{array} \right.$	$\left\{ \begin{array}{l} \text{---} \\ \text{---} \\ \text{---} \end{array} \right.$	$\left. \right\} 4 \ 8$	65	4.5	{ Small eared; prolific.

*Notes on varieties of cotton.*

Cotton. {Field No. (Row) 6.  
 {Variety: Dickson Cluster.

I. Bolls, position. {Cluster, semicluster, noncluster: Cluster.  
 {Terminal or nonterminal, ———

II. Stalk..... {Base limbs .. {Number: 2 to 5, generally 2 to 3.  
 {Length: Medium.  
 {Internodes: Medium.  
 {Upper limbs—Length: Short.  
 {Compactness: Erect.  
 {Height: Medium.

III. Bolls..... {Weight ..... {10.  
 {10.  
 {10.  
 {Size (field estimate), ———  
 {Point: Both acute and blunt.  
 {Adherence, ———

IV. Seed .....	{	Percentage of lint, ——					
		Weight .....	{	50.			
			{	50.			
			{	50.			
		Shape and size, ——					
		Color, ——					
V. Earliness .....	{	Field estimate: Very early.	a	b	c	Average.	
		Number open....	54	29	31	38	
		Number grown ..	3	6	21	10	
		Number younger..					
		3 best plants.					
		Total.....	57	35	52	48	
		Percentage of bolls open, 79.					
VI. Prolificacy .....	{	Selected plants (field estimate); percentage, 100.					
	{	3 best plants (office), ——					
VII. Lint (field estimate), ——							

### THE COLLEGE OF AGRICULTURE OF THE UNIVERSITY OF ILLINOIS.

The college of agriculture is one of the six colleges of the University of Illinois. Candidates for admission to the college of agriculture are required to have the same number of high school credits as candidates for admission to other colleges of the university.

This number is 40 credits at the present time, but it will be increased to 42 credits in 1905. By the term credit is meant the work in a subject continuously pursued with daily recitations through one of the three terms of the high school year; or, in other words, the work of 60 recitation periods of forty minutes each, or, the equivalent in laboratory or other practice. Of the total number of credits required for admission, 9 must be in English, 7 in mathematics, and 6 in science and history. For graduation from the college of agriculture, students are required to have obtained 130 university credits. By the university credit is meant a class period a week for one semester, each class period presupposing two hours' preparation by the student, or the equivalent in laboratory, shop, or field practice. The work for 79 credits is prescribed as follows:

15 credits in agronomy.	5 credits in botany.
5 credits in thremmatology.	5 credits in zoology.
2½ credits in animal husbandry.	2 credits in economics.
2½ credits in dairy husbandry.	6 credits in rhetoric.
8 credits in horticulture.	5 credits in military science.
15 credits in chemistry.	3 credits in physical training.
5 credits in geology.	

Of the remaining 56 credits required for graduation at least 4½ must be chosen in animal husbandry or dairy husbandry, 5 in natural history, 3 in English, and 25 in technical agriculture. The remaining credits may be obtained from any subjects offered in the university

which the student is prepared to take, provided only that two years of foreign language must be taken in the university if not offered for admission. A thesis is also required for graduation for which from 5 to 10 credits will be allowed according to the nature of the subject.

The students in the college of agriculture are given courses in English or other languages in the college of literature and arts; courses in chemistry, physics, geology, botany, zoology, mathematics, etc., in the college of science; blacksmithing, carpentry, etc., in the college of engineering, the work of the college of agriculture being devoted to the subject of agronomy, animal husbandry, dairy husbandry, horticulture, and veterinary science, or, in other words, to the subjects in technical agriculture.

In the department of agronomy 15 courses are offered (not including the courses in farm mechanics), which are described briefly in the following excerpts from the college catalogue:

The semester, the days, and the class period or periods during which each course is given, and the number of credits per semester for which the course counts are shown after each course, as follows: The semester is indicated by the Roman numerals I, II; the days, by the initial letters of the days of the week; the class period or periods (of which there are nine each day, numbered consecutively from 1 to 9), by Arabic figures; and the amount of credit, by Arabic figures in parentheses. For example, the abbreviations I; M., W., F.; 1; (3) are to be read first semester, Monday, Wednesday, and Friday, first period, three credits.

1. *Drainage and irrigation*.—Location of drains and irrigation conduits, leveling, digging, laying tile and pipes, filling, and subsequent care; cost of construction and efficiency; sewers for the disposal of waste water from farm buildings and the sewage from kitchen and toilet; farm water pipes, pipe and thread cutting. Class work, laboratory and field practice. I; first half; daily; 6, 7; ( $2\frac{1}{2}$ ).

5. *Farm crops—Quality and improvement*.—Judging of corn (see Exhibit 3, p. 30) and oats, wheat grading, methods of improving quality, shrinkage of grain, care of stored crops to prevent injury and loss. Class and laboratory work. I; first half; daily; 6, 7 (or 3, 4); ( $2\frac{1}{2}$ ).

6. *Farm crops—Germination and growth*.—Vitality and germination of seeds, preservation of seeds, methods of seeding; conditions of plant growth; peculiarities of the different agricultural plants in respect to structure, habits, and requirements for successful growth; enemies to plant growth; weeds and weed seeds, their identification and methods of destruction; fungus diseases, such as smut of oats and wheat, and blight, scab, and rot of potatoes, methods of prevention; insects injurious to farm crops and how to combat them. Class room, laboratory, and field work. II; first half; daily; 6, 7; ( $2\frac{1}{2}$ ).

7. *Special crops*.—A special study of farm crops taken up under an agricultural outline—grain crops, root crops, forage crops, sugar and fiber crops—their history and distribution over the earth, methods of culture, cost of production, consumption of products, and residues or by-products. Class work, supplemented by practical field work and a study of the results of previous experiments, such as detasseling corn, injury to roots of corn by cultivation, selection and breeding of corn and other crops, with special reference to practices which apply directly to Illinois conditions. Students will have an excellent opportunity to study the work of the Agricultural experiment station. II; daily; 1, 2; (5). Required: Agronomy 2, 5, 6.

8. *Field experiments*.—Special work by the students conducted in the field. This work consists in testing varieties of corn, oats, wheat, potatoes, and other farm crops;

methods of planting corn, seeding grains, grasses, and other forage crops; culture of corn, potatoes, and sugar beets; practice in treating oats and wheat for smut and potatoes for scab and studying the effects upon the crops; combating chinch bugs and other injurious insects. Other practical experiments may be arranged with the instructor. Special opportunities will be given to advanced students of high class standing to take up experiments, under assignment and direction of the instructor in farm crops, on certain large farms in the State, arrangements having been made with the farm owners or managers for such experiments. II, second half, and summer vacation; daily; arrange time; ( $2\frac{1}{2}$  to 5).

Required: Agronomy 7, 12.

9. *Soil physics and management*.—This course is designed to prepare the student better to understand the effects of the different methods of treatment of soils and the influence of these methods upon moisture, texture, aeration, fertility, and production. It comprises a study of the origin of soils, of the various methods of soil formation, of their mechanical composition and classification; also soil moisture and means for conserving it, soil texture as affecting capillarity, osmosis, and diffusion, as affected by plowing, harrowing, cultivating, rolling, and cropping; of the wasting of soils by washing; fall or spring plowing and drainage as affecting moisture, temperatures, and root development. The work of the class room is supplemented by laboratory work, comprising the determination of such questions as specific gravity, relative gravity, water-holding capacity and capillary power of various soils; also the study of the physical effects of different systems of rotation and of continuous cropping with various crops, and the mechanical analysis of soils. I; daily; 1, 2; (5).

Required: Physics 1, 3 (first semester's work), and Agronomy, 2.

10. *Special problems in soil physics*.—This work is intended for students wishing to specialize further in the study of the physical properties of soils, and will include the determination by electrical methods of the temperature, moisture, and soluble salt content of various soils under actual field conditions; effect of different depths of plowing, cultivation, and rolling on soil conditions; effect of different methods of preparing seed beds; the physical questions involved in the formation and redemption of the so-called "alkali," "barren" or "dead dog" soils, and of other peculiar soils of Illinois. II, or summer vacation; daily; arrange time; (5).

Required: Agronomy 9.

11. *Soil bacteriology*.—A study of the morphology and activities of the bacteria which are connected with the elaboration of plant food in the soil, or which induce changes of vital importance to agriculture, with regard to the effects of cropping and tillage upon these organisms, and with special reference to the study of those forms which are concerned with the formation of nitrates and nitrites in the soil and with the accumulation of nitrogen by leguminous crops. Class room and laboratory work. II; daily; 6, 7; (5).

Required: Botany 5; Chemistry 3b, 4.

12. *Fertilizers, rotations, and fertility*.—The influence of fertility, natural or supplied, upon the yield of various crops; the effect of different crops upon the soil and upon succeeding crops; different rotations and the ultimate effect of different systems of farming upon the fertility and productive capacity of soils. The above will be supplemented by a laboratory study of manures and fertilizers, their composition and their agricultural and commercial value; of soils cropped continuously with different crops and with a series of crops; of the fertility of soils of different types, or classes from different sections of Illinois. II; daily; 1, 2; (5).

Required: Chemistry 13; Agronomy 6, 9.

13. *Investigation of the fertility of special soils*.—This course is primarily designed to enable the student to study the fertility of those special soils in which he may be particularly interested, and to become familiar with the correct principles and methods of such investigations. It will include the determination of the nature and

quantity of the elements of fertility in the soils investigated, the effect upon various crops of different fertilizers added to the soils, as determined by pot cultures, and, where possible, by plat experiments. This work will be supplemented by a systematic study of the work of experiment stations and experimenters along these lines of investigations. I, II; arrange time; (2 to 5).

Required: Agronomy 12.

14. *History of agriculture*.—Its development and practice, with particular regard to the agriculture of those nations which have contributed most to agricultural progress, including a sketch of the earliest agricultural practices as illustrated by the agriculture of the Egyptians, the Jews, the Chinese, and other ancient peoples; followed by a study of the development of Roman agriculture and its influences upon the practices in other nations; a consideration of the beginnings and systems of British agriculture with regard to their influence upon social conditions; and, finally, the development of modern agriculture with special reference to that of England, Germany, France, and the United States. I, second half; daily; 3; ( $2\frac{1}{2}$ ).

15. *Comparative agriculture*.—Influence of locality, climate, soil, race, customs, laws, religion, etc., upon the agriculture of a country, and incidentally upon its people. One crop only, and its effect, as rice; Indian corn in American agriculture and affairs. Varying conditions under which the same crop may be produced, as wheat. Statistical agriculture. Influence of machinery and of land titles, whether resting in the government, in landlord, or in occupant. Relation of agriculture to other industries and to the body politic. Lectures. II; F; 4; (1).

Required: Two years of University work.

16. *German agricultural readings*.—A study of the latest agricultural experiments and investigations published in the German language, special attention being given to soils and crops. The current numbers of German journals of agricultural science will be required and used as a text. This course is designed to give the student a broader knowledge of the recent advances in scientific agriculture, and, incidentally, it will aid him in making a practical application of a foreign language. It is recommended that it be taken after Agronomy 12. II; M., W.; 4; (2).

Required: Two years' work in German.

17. *Special work in drainage and machinery*.—Students may arrange for special work in any of the lines covering drainage or farm machinery, either in the second semester or the summer. ( $2\frac{1}{2}$  to 5.)

18. *Investigation and thesis*.—This course varies in the subject matter of study, according to the department in which theses are written. The work is under the direction of the head of the department. I, II; arrange time; (5 to 10).

The offices, class rooms, and laboratories of the department of agronomy are housed in the agricultural building (Pl. I), which was recently completed at a cost of \$150,000. It consists of four separate structures built around an open court and connected by corridors. The main building is 248 feet long and from 50 to 100 feet wide, and three stories high. The other three buildings are 45 by 116 feet, and two stories high. These buildings are of stone and brick, roofed with slate, and contain, all told, 113 rooms and a total floor space of nearly 2 acres. An adjacent glass structure includes a photographic laboratory and a pot-culture laboratory for the department of agronomy. Several acres of land near to the agricultural buildings are used for instruction in agronomy, chiefly by means of student experiments.

Aside from the work in farm mechanics, the department of agronomy includes four principal divisions, viz, soil fertility, soil physics, soil

bacteriology, and farm crops. Several courses of instruction are offered in each of these divisions, and in each case instruction is given by the laboratory method, as well as by text-books, lectures, and reference readings. Two laboratories are provided for the work in soil fertility. One of these is used for the analysis of soils, fertilizers, and manures; for the determination of the elements of plant food contained in plants and plant products, and for the preparation of soils for pot culture experiments, which include the use of sand cultures, water cultures, and soil cultures, with the addition or elimination of any or all of the different elements of plant food (Pl. III, fig. 1). The second is the pot-culture laboratory (Pl. III, fig. 2), which is located in the greenhouse near the agricultural building, and in which the pot-culture experiments are carried on by the student as a part of his regular laboratory practice. The soil fertility analytical laboratory is provided with desks for 18 students' places, each desk being made double, so that by working two sections 36 students can be accommodated. All apparatus necessary for the analysis of soils, fertilizers, etc., is provided, including analytical balances, digestion furnaces, distillation apparatus, glass and porcelain ware, etc. The laboratory is provided with a hood under which operations which give off poisonous or disagreeable fumes or odors are performed. The desks are piped for gas, compressed air, vacuum and water, and provided with sinks and waste pipes. The fertility pot-culture laboratory is provided with suitable tables and with several hundred glazed pots of different sizes suitable for pot-culture experiments. Most of the water used in the pot-culture experiments is drawn from a 400-barrel cistern, which is kept full of exceedingly pure soft water collected from the slate roof of the agricultural building, which is a quarter of a mile distant from the central heating plant of the university, and hence is very free from coal smoke, etc., from the chimneys. For special purposes, distilled water is provided and, when necessary, nitrogen-free water is used.

The soil physics laboratory (Pl. IV, fig. 1) is provided with a sufficient number of desks to allow 24 students to work at one time, and, by running two sections, 48 students can be accommodated. This laboratory is well equipped with the apparatus necessary for studying the physics of soil, including centrifugal machines and shaking apparatus used in mechanical analyses (fig 1), microscopes, balances, compacting apparatus, apparatus for determining the water content, absorptive capacity, water-holding power, and specific gravity of soils; several electrical instruments for the determination of temperature, moisture, and soluble salt-content of soils; a 3-horsepower electric motor with a line shaft, counter shaft, belting, etc.; elutriators, furnaces, sieves, and much other general apparatus. The laboratory is also provided with a side table, hood, large drying oven, and store-

room. For the work in farm drainage the department of agronomy is provided with several surveyors' leveling instruments, chains, and tapelines, and all necessary tools for running ditches and laying tile. Students are given a considerable amount of practice in surveying systems of drainage, running levels, digging ditches, and laying tile.

Two laboratories are provided for the study of soil bacteriology, although one of these is also used during part of the year for beginning students in general bacteriology. Thirty-two student places are provided for. The laboratory is equipped with incubators, micro-

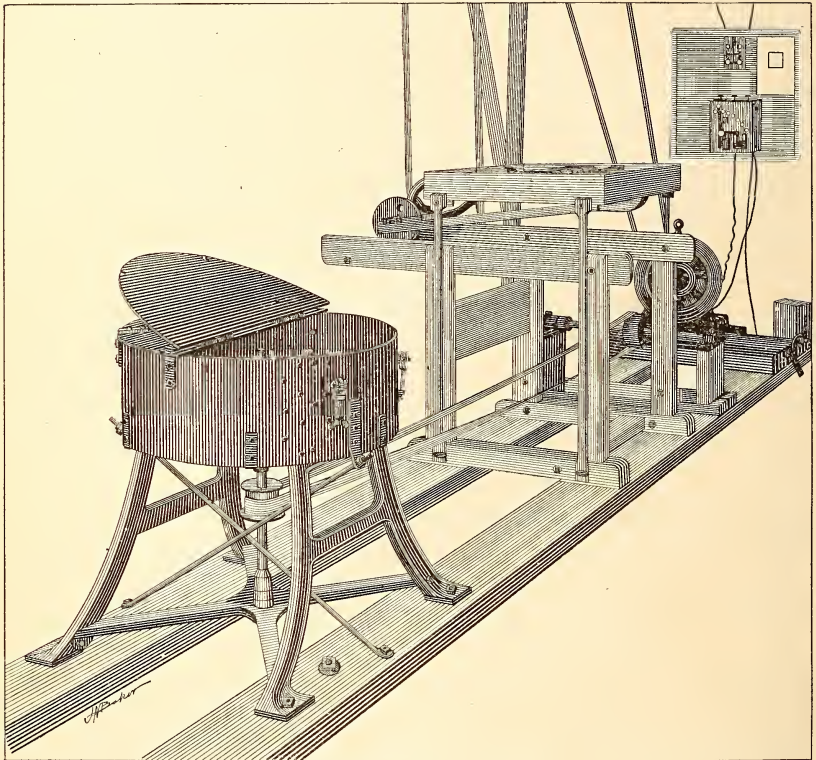
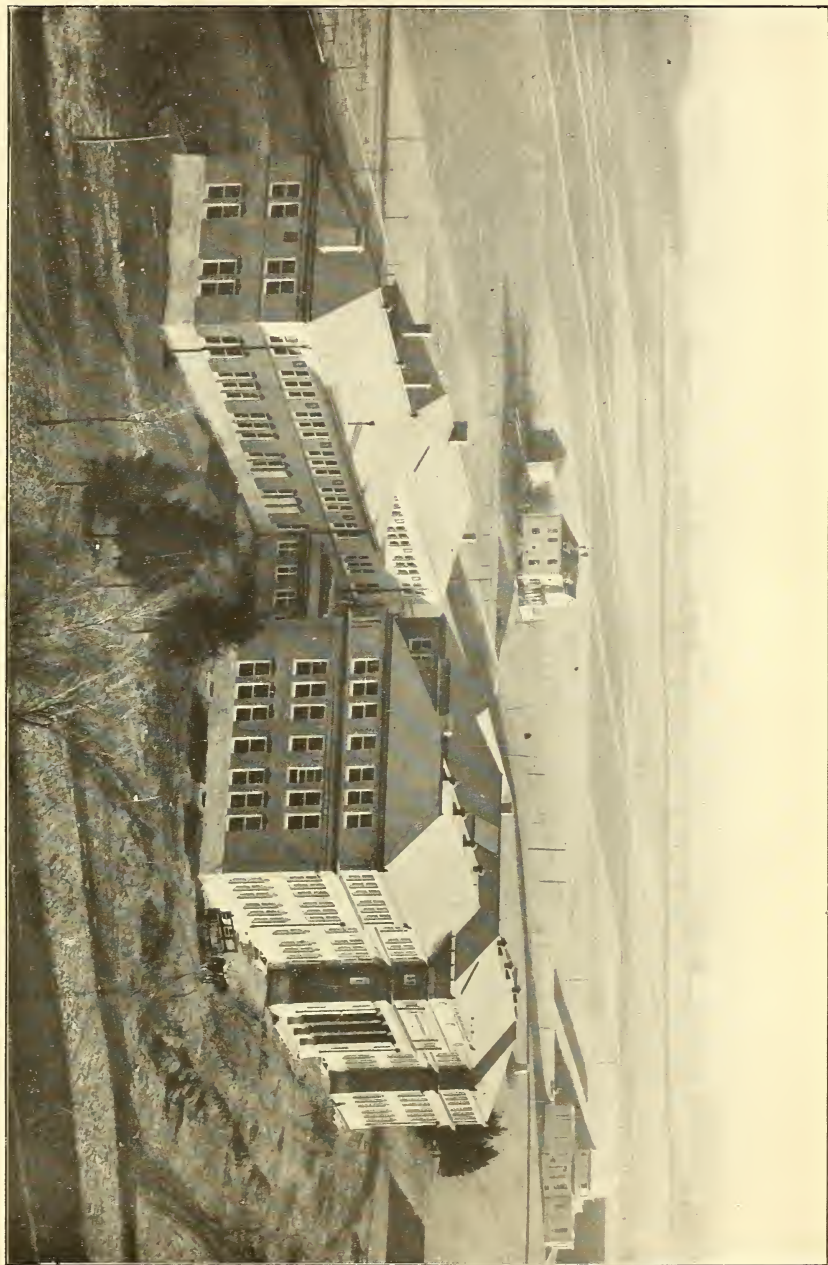


FIG. 1.—Centrifuge, shaker, and electric motor used in mechanical analysis of soils.

scopes, autoclaves and other sterilizing apparatus, balances, and other materials needed for bacteriological work, including staining solutions, chemicals, media, etc. The hood tables and the tile-top side tables are provided with steam baths, gas, air, vacuum, and water pipes, and waste sinks. Adjoining the laboratory are a store room, an incubating room, and an animal room with cages for keeping animals under experiment.

Two laboratories are provided for the work in farm crops (Pl. IV, fig 2), one of which has 36 student places, and the other 24 places,



UNIVERSITY OF ILLINOIS—BIRD'S-EYE VIEW OF AGRICULTURAL BUILDING AND EXPERIMENT FIELDS





FIG. 1.—UNIVERSITY OF ILLINOIS—CLASS IN AGRONOMY STUDYING ROOT DEVELOPMENT OF CORN.



FIG. 2.—UNIVERSITY OF ILLINOIS—CLASS IN AGRONOMY COLLECTING SAMPLES OF SOIL.



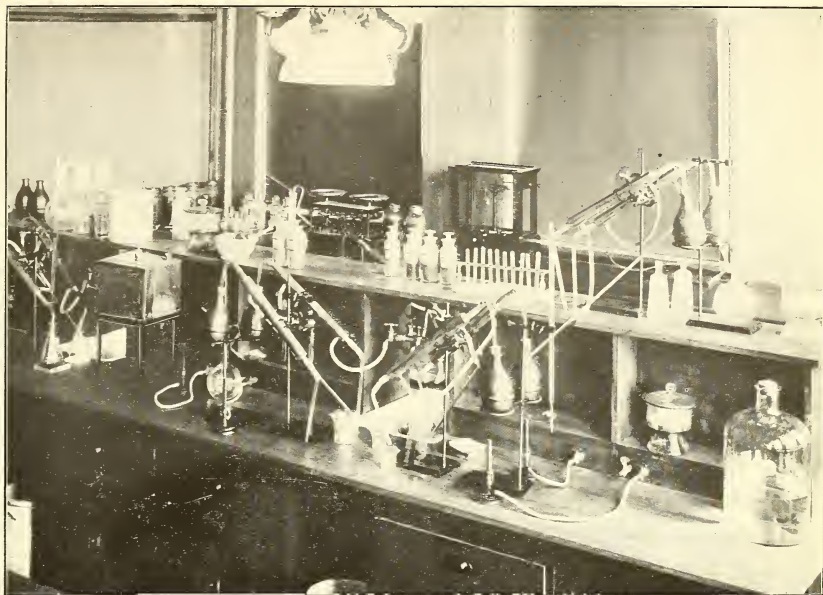


FIG. 1.—UNIVERSITY OF ILLINOIS—SOIL FERTILITY LABORATORY FOR ANALYSIS AND SYNTHESIS OF SOILS AND FERTILIZERS.



FIG. 2.—UNIVERSITY OF ILLINOIS—CLASS IN AGRONOMY IN POT CULTURE LABORATORY.



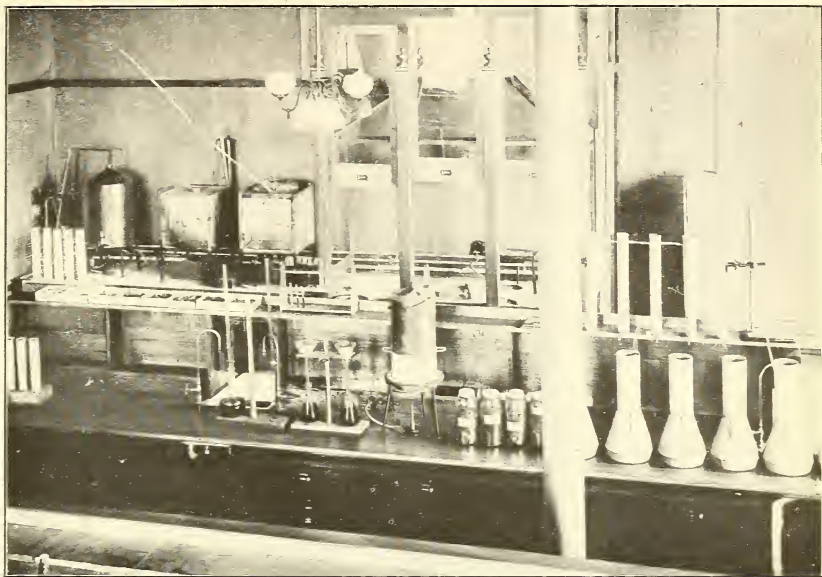


FIG. 1.—UNIVERSITY OF ILLINOIS—SOIL PHYSICS LABORATORY.



FIG. 2.—UNIVERSITY OF ILLINOIS—FARM CROPS SEED LABORATORY.



making it possible to have 60 students in farm crops at work at one time. These desks are provided with a large number of drawers for different samples of grains and equipped with small microscopes, tape measures, scales, germinating apparatus, etc. The laboratory is provided with one side case, containing 253 drawers for samples of corn of ten ears each, used in instruction in corn judging and the study of varieties of corn. There are a large number of tilting bins, holding from 1 to 3 bushels of corn, and a large wall case contains six upright bins, reaching nearly to the ceiling of the room, each of several bushels' capacity, used for holding a supply of some of the stock grains used in the farm crops work. There are six large herbarium cases for preserving specimens of different farm crops and of weeds injurious to farm crops. There is also a cabinet provided with a large number of cases for a collection of insects injurious to farm crops. Adjoining the farm crops student laboratory is a large germinating room, about 7 feet wide and 20 feet long, with wide shelving around the walls, extending from near the floor to the ceiling, giving sufficient space for several hundred germinators. This room is provided with steam coils with valves so arranged that any number of coils can be used and the temperature of the room regulated as may be desired. A large electric incubator is also provided for special germination studies. Besides the laboratory practice the students in farm crops carry on plat experiments under field conditions, several acres being provided for this purpose and hand tools being provided for student use.

Among the text-books and reference books most largely used in the course in soil fertility are Aikman's *Manures* and the *Principles of Manuring*, Voorhees's *Fertilizers*, Roberts's *Fertility of the Land*, Johnson's *How Crops Feed*, Snyder's *Chemistry of Soils and Fertilizers*, Storer's *Agriculture*, Liebig's *Agricultural Chemistry*, Lawes and Gilbert's *Reports on Agricultural Investigations at Rothamsted*, and the bulletins and reports of the United States Department of Agriculture and of the various State experiment stations.

Among the books used in soil physics are *The Soil and The Physics of Agriculture*, by King; *Rocks and Soils*, by Stockbridge; *Origin and Nature of Soils*,<sup>a</sup> by Shaler; and *Land Drainage*, by Miles.

Books used in soil bacteriology are *Manual of Bacteriology*, by Sternberg; *Conn's Agricultural Bacteriology*; and *Fischer's Structure and Functions of Bacteria*.

Among the books used in the study of farm crops are Johnson's *How Crops Grow*; *Beal's Grasses of North America*; *Corn Plants*, by Sargent; *Plant Breeding*, by Bailey; *Weeds and How to Eradicate Them*, by Shaw; and Storer's *Agriculture*.

In addition to these books the library of the University of Illinois

<sup>a</sup>Twelfth Annual Report of the U. S. Geological Survey, Part I—Geology, pp. 213-345.

contains several hundred volumes, journals, and pamphlets, in English, German, and French, relating in part or wholly to the subject of agronomy. These are accessible to all of the students in the department, but are used more largely by students engaged in research work.

Laboratory, lecture, or field notebooks are required to be kept by students in all courses in agronomy, and in most courses students are required to prepare two or three essays of from 1,000 to 5,000 words each during the semester. As a rule, preliminary examinations are given at the end of each month and a final examination at the close of the course. The student's standing or grade for the semester's work is based upon four factors: (1) Class records of recitations; (2) preliminary examinations and written exercises; (3) lecture, laboratory, or field notebooks; and (4) final examinations.

During the past year about 200 students took work in courses in agronomy. Advanced classes numbered from 12 to 25 students and lower classes contained from 30 to 75 students. Excursions are occasionally made by classes to examine soils, inspect drainage systems, to visit fields and other places of special interest and importance to the work of the classes.

Aside from the help of several student assistants, there are six regular instructors in the department of agronomy. One offers courses in soil fertility, another in soil physics, a third in farm drainage and irrigation, a fourth in soil bacteriology, and two other instructors give courses in farm crops.

#### EXHIBIT No. 3.

#### JUDGING CORN.

Students in farm crops, when judging corn, are provided with stiff cardboard covers 9 by  $4\frac{3}{4}$  inches, in which special blank forms for scoring may be fastened. On the inside of the front cover is pasted Form A, giving standards for varieties, explanation of points, and rules to be used in judging. On the inside of the back cover and fastened to it by brass paper fasteners are forms B and C. Form B is used by the student in scoring a single ear of corn, and Form C for recording the corrected scores of several ears.

#### FORM A.—*Directions for scoring.*

##### STANDARDS FOR VARIETIES.

Name of variety.	Length of ear.	Circumference of ear.	Proportion of corn to cob.
	<i>Inches.</i>	<i>Inches.</i>	<i>Per cent.</i>
Reid Yellow Dent.....	10	7	88
Golden Eagle.....	9	7	90
Riley Favorite.....	9	7	90
Leaming.....	10	7	88
Boone County White.....	10	7.5	86
Silver Mine.....	9	7	90
White Superior.....	8.5	7	88
General.....	10-11	7.5-8	88

## EXPLANATION OF POINTS.

1. Uniformity: Uniform shape, size, indentation, and type of ears.
2. Shape: Shape of ear should conform to variety type, usually cylindrical, i. e., of equal circumference from butt to tip.
3. Color: Free from mixture and true to variety color.
4. Market condition: Ripeness, soundness, ear firm and well matured.
5. Tip: Kernels filled over the tip in regular manner.
6. Butt: Kernels swelled about ear stalk, leaving deep depression when shank is removed.
7. Kernel, uniformity: Uniform shape, size, and conformity to variety type.
8. Kernel, shape: Wedge shaped, straight edges, and large germ.
9. Length: Varies with the variety, measure.
10. Circumference: Varies with the variety, measure.
11. Space: Furrow between tops of rows of kernels.
12. Proportion: Proportion of weight of grain to cob. Weight varies with variety.

## RULES TO BE USED IN JUDGING.

1. The deficiency and excess in length of all ears not conforming to the standard for the variety shall be added together, and for every 2 inches thus obtained a cut of one point shall be made. In determining length, measure from the extreme tip to the extreme butt.
2. The deficiency and excess in circumference of all ears not conforming to the standard of the variety shall be added together, and for every 4 inches thus obtained a cut of one point shall be made. Measure the circumference at one-third the distance from the butt to the tip of the ear.
3. In determining the proportion of corn to cob, weigh every alternate ear in the exhibit. Shell and weigh the cobs, and subtract from weight of ears, giving the weight of corn. Divide the weight of corn by total weight of ears, giving the per cent of corn. For each per cent short of standard for the variety a half-point cut shall be made.
4. In judging color, a red cob in white corn, or a white cob in yellow corn, shall be cut ten points. For one or two mixed kernels, a cut of one-fourth point; for three or four mixed kernels, a cut of one-half point; for five mixed kernels, a three-fourths-point cut; or for six or more mixed kernels, a one-point cut shall be made. Kernels missing from the ear shall be counted as mixed. Difference in shade of color, as light or dark red, white or cream color, must be scored according to variety characteristics.
5. To determine the cut for space, the following rules can be applied if combined with the judgment of the student: For less than one thirty-second inch, no cut; for a furrow one thirty-second to one-sixteenth inch, one-half point; for more than one-sixteenth inch, cut one point. The looseness of kernels on the cob does not apply to space, but to maturity. The furrows or angle between the tops of the rows of kernels is the space between rows.

FORM B.—*For individual sample.*

## STUDENT'S REPORT JUDGING CORN.

Date, ———, ———, ———.

Number of exhibit, ———.

Name of variety, ———.

## STANDARD OF VARIETY.

Length, ———.

Circumference, ———.

Proportion grain to cob, ———.

	Points.	Student's score.	Corrected score.	Instructor's score.
1. Uniformity .....	10	.....	.....	.....
2. Shape .....	5	.....	.....	.....
3. Color .....	10	.....	.....	.....
4. Market condition .....	5	.....	.....	.....
5. Tips .....	10	.....	.....	.....
6. Butts .....	5	.....	.....	.....
7. Kernel uniformity .....	5	.....	.....	.....
8. Kernel shape .....	5	.....	.....	.....
9. Length .....	10	.....	.....	.....
10. Circumference .....	5	.....	.....	.....
11. Space .....	10	.....	.....	.....
12. Proportion .....	20	.....	.....	.....
Total .....	100	.....	.....	.....

## REMARKS.

FORM C.—*For several samples.*

	Points.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Uniformity .....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2. Shape of ear .....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3. Purity of color .....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4. Market condition .....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5. Filling out tips .....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6. Filling out butts .....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7. Kernel uniformity .....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8. Kernel shape .....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9. Length .....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10. Circumference .....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11. Space between rows .....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12. Proportion of corn to cob .....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total .....	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

## EXHIBIT No. 4.

## STUDENT'S LABORATORY BLANKS IN SOIL PHYSICS.

*Experiment No. 1.*

## MOISTURE—CAPILLARY.

Use sand, clay, loam, and gravel as provided.

1. Weigh carefully four drying pans.
2. Place in one of each about 100 grams of each of the above soils.
3. Weigh the pan and soil carefully.
4. Spread out the soil to a thin layer by shaking, and dry for twenty-four hours at room temperature.
5. Weigh and repeat the drying and weighing at intervals of four to five hours until a nearly constant weight is obtained.

The loss of weight represents the amount of capillary water.

Amount of capillary water found was: Sand, ———; clay, ———; loam, ———; gravel, ———.

Define capillary water: ——— ———.

*Experiment No. 2.*

## DETERMINATION OF HYGROSCOPIC MOISTURE.

Use the air-dried soils from experiment No. 1.

1. Place about 10 grams of the air-dried soil in a tared porcelain crucible (*a*).
2. Weigh the soil and crucible (*b*) and heat in the air bath at 100 to 110° C. for 1 hour.
3. Cool in a desiccator and weigh rapidly to prevent absorption of moisture from the air.
4. Heat for a shorter time, cool, and weigh, repeating until the weight (*c*) becomes constant.

Calculation: The loss of weight, or  $b-c$ , equals the amount of hygroscopic water in the sample taken.

$c-a$  equals the weight of water-free soil.

Therefore  $\frac{b-c}{c-a}$  = per cent of hygroscopic water expressed on the basis of water-free soil.

The per cent of hygroscopic water found was: Sand, ———; clay, ———; loam, ———; gravel, ———.

Define hygroscopic water: ——— ———.

From the results obtained in experiments 1 and 2 compute the percentage of capillary and total water in the soil, expressed on the basis of water-free soil.

Total water content is (percentage). Sand, ———; clay, ———; loam, ———; gravel, ———.

In addition to the capillary and hygroscopic water, the soil may contain, under some conditions, as immediately after a rain, a certain amount of free or gravitational water. This portion of the soil water is acted upon by the force of gravity, which causes it to percolate downward to the level of the ground water.

*Experiment No. 3.*

## HILGARD'S FLOCCULATION EXPERIMENT.

Two students will work conjointly in this experiment.

1. Into each of four beakers place about 1 gram of clay and add 200 cubic centimeters of water.

2. To beaker—

No. 1 add 0.2 gram calcium hydrate=0.1 per cent solution.

No. 2 add 1 gram calcium hydrate=0.5 per cent solution.

No. 3 add 2 grams calcium hydrate=1 per cent solution.

No. 4 add 0 gram calcium hydrate=Control.

3. With a stirring rod mix the contents of each beaker thoroughly and then place a sample of each in a Nessler's cylinder and whirl in the centrifuge at the lowest speed and note the time required to completely precipitate each solution.

4. Pour the contents of each cylinder back into the respective beaker, stir thoroughly and set aside, observing occasionally to determine the time required for complete sedimentation in each case.

Compare in each case the cylinders and beakers containing the different strengths of solution and the control and tabulate the results in the space below.

	Time to centrifugate.	Time to sediment.
0.1 per cent solution .....	.....	.....
0.5 per cent solution .....	.....	.....
1 per cent solution .....	.....	.....
Control .....	.....	.....

Explain how the lime acts and clarifies the water: ——— ———.

*Experiment No. 4.*

## EFFECTS OF LIME ON PLASTIC SOILS.

Two students will work together as in experiment No. 3.

1. Weigh out five 50-gram samples of the clay soil.

2. To sample—

No. 1 add 0.5 per cent calcium hydrate.

No. 2 add 1 per cent calcium hydrate.

No. 3 add 5 per cent calcium hydrate.

No. 4 add 10 per cent calcium hydrate.

No. 5 add no calcium hydrate.

3. Mix each sample thoroughly in a soil pan, and add just enough water to make plastic.

4. Fill into molds in the form of sticks, using care to compress all samples to the same degree, and transfer to the oven and bake at 110° C. for 4 to 5 hours.

5. Test the strength of each stick of baked clay by supporting upon blocks and suspending weights until the clay is fractured. Note weight required in each case and fill in results below:

Grams.

0.5 per cent broke with.....  
 1 per cent broke with.....  
 5 per cent broke with.....  
 10 per cent broke with.....  
 Control broke with.....

Explain the loss of plasticity due to the lime: ——— ———.

*Experiment No. 5.*

## DETERMINATION OF THE APPARENT SPECIFIC GRAVITY OF SOILS.

Use each of the four soils as in former experiments.

1. Weigh carefully in empty and thoroughly cleaned soil tube (*a*).

2. Fill it with one of the soils to be tested, which must first be well pulverized if lumpy. In filling use the soil-compacting machine, allowing the weight to fall three times from the 6-inch mark upon each cupful of soil. Fill the tube to the crease near the top.

3. Weigh the filled tube carefully (*b*).

4. The area of the bottom of the tube is 20 square centimeters. From this compute the number of cubic centimeters of soil which it contains (*c*).

5. Determine the amount of hygroscopic moisture in a special sample of the soil, according to direction given under Experiment No. 2 (*d*).

*Calculations—*

$$b - (a + d) = \text{weight of the given volume of soil.}$$

$$\text{Therefore, } \frac{b - (a + d)}{c} = \text{weight of 1 cc. of soil} = \text{volume weight of soil.}$$

$$\frac{\text{Volume weight of soil}}{\text{Volume weight of water}} = \text{apparent specific gravity.}$$

I find the apparent specific gravity to be as follows: Sand, ———; gravel, ———; loam, ———; clay, ———.

The volume weight or apparent specific gravity of soils varies with the amount of packing, a freshly plowed field being much lighter per cubic foot than one compacted by rains or tramping.

Explain the object of using the soil-compacting machine in this experiment. ——— ———.

*Experiment No. 9.*

## DETERMINATION OF THE POWER OF LOOSE SOILS TO RETAIN MOISTURE.

1. Place 100 grams of the air-dried soil in a beaker and add 100 cubic centimeters of distilled water.

2. Mix the soil and water thoroughly and rinse the soil upon a previously saturated filter with a known amount of distilled water. Cover the top of the funnel with a glass plate to prevent evaporation.

3. Catch the water which drains away, in a graduate, and deduct the amount of water caught from the total amount used. The remainder represents the amount retained by the soil.

4. With a special sample of the soil used determine the per cent of hygroscopic water.

*Calculation.*—After finding the per cent of hygroscopic water, determine the amount of water-free soil in the 100-gram sample taken. Add the total amount of hygroscopic water to the capillary water retained and divide the sum by the weight of water-free soil, and the quotient will represent the per cent of water held, calculated on the basis of water-free soil.

Per cent of water retained was: Sand, ———; clay, ———; loam, ———; gravel, ———.

Why do you use air-dried soil in this experiment? ———.

Why do you moisten the filter? ———.

—————

*Experiment No. 12.*

## DETERMINATION OF THE RATE OF PERCOLATION OF AIR THROUGH SOILS.

1. Fill the series of tubes provided for this experiment with the finely pulverized and sifted soils without compacting.

2. Attach the tubes successively to the aspirator and note the length of time required to force or draw 10 liters of air through each sample of soil. The aspirator weight must be started from the same height in each case.

This experiment illustrates the relative aeration of soils, a question which is of importance in connection with the subject of the growth and development of the nitrifying and other bacteria of the soil concerned in the production of plant food.

Time required for sand, ———; gravel, ———; loam, ———; clay, ———.

—————

*Experiment No. 13.*

## CAPILLARY ATTRACTION OF SOILS.

1. Close the lower end of 12 of the large glass tubes by a piece of thin muslin tied firmly to the tubes. The tubes are then filled with the finely pulverized air-dried soils, which have been carefully sifted to remove all small stones. These tubes are to be filled with each soil—No. 1, by simply pouring the soil as loosely as possible into the tube; No. 2, by compacting the soil gently by tapping the lower end of the tube upon the bench, and No. 4, by compacting the soil by ramming with a rod. Care must be taken to compact the different soils to the same degree, both in the jarring and ramming, by jarring or ramming each tube the same number of times.

The tubes are now placed in the supporting frame in such a manner that the lower ends shall dip one-half inch beneath the surface of a tray of water.

The experiment is now ready for observation at intervals of twenty-four hours, when the height to which the water has risen is carefully measured and recorded.

These observations should be taken daily for one week, and the results are to be noted below.

Day.		Sand.			Gravel.			Loam.			Clay.		
		No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.
1	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	{Rise.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	{Total height.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

To obtain accurate and reliable results it is necessary to use great care in filling the tubes, observing in particular that there are no places where the column of soil is unevenly packed or broken by coarse material which will prevent the action of capillarity.

#### *Experiment No. 14.*

##### EFFECT OF CULTIVATION OR DUST MULCHES ON EVAPORATION OF WATER FROM SOILS.

Fill all the tubes with the fine prairie soils, using the compacting machine. All the tubes should be filled to the same level.

The conical bases of the tubes are then filled partly full of water, so that the water shall stand at the same level in each. Determine the level with the S-shaped glass tube, and measure the depth of water very accurately with the millimeter rule. The tubes are to be filled to the same level each day, and the amount of water added is carefully noted. This amount represents the water lost by evaporation. The tubes are treated as follows: Tube 1, control; tube 2, cultivated 1 inch; tube 3, cultivated 2 inches; tube 4, cultivated 3 inches; tube 5, cultivated 4 inches; tube 6, cultivated 5 inches.

The cultivation is performed each day by removing a layer of soil to the depth of cultivation used in the tube, and thoroughly mixing it, when it is replaced.

Each tube has an area of 80 square centimeters = 12.4 square inches =  $\frac{1}{505858}$  acre, and the results are to be computed in tons of water evaporated per acre. The observations are to be taken for seven days and the results filled in below.

Depth of culture.....	0 in.	1 in.	2 in.	3 in.	4 in.	5 in.
Total number grams.....	.....	.....	.....	.....	.....	.....
Tons per acre.....	.....	.....	.....	.....	.....	.....

#### *Experiment No. 15.*

##### EFFECT OF ARTIFICIAL MULCHES UPON EVAPORATION OF WATER FROM SOILS.

This experiment is conducted in a similar manner to the last, excepting that the tubes are all filled to the same level and used as follows: No. 1, control; No. 2, 2 inches sand; No. 3, 2 inches clay; No. 4, 2 inches muck; No. 5, 2 inches sawdust; No. 6, 2 inches cut straw.

##### RESULTS.

	Control.	Sand.	Clay.	Muck.	Sawdust.	Cut straw.
Total number grams.....	.....	.....	.....	.....	.....	.....
Tons per acre.....	.....	.....	.....	.....	.....	.....

## MICHIGAN AGRICULTURAL COLLEGE.

The agricultural course in this college requires four or five years for completion, depending on the preparation of the candidates for admission, and leads to the degree of bachelor of science. The entrance examinations for the five-year course cover the following subjects: Arithmetic, geography, grammar, reading, spelling, penmanship, and history of the United States. The holder of a teacher's certificate, or eighth-grade diploma signed by a county commissioner and issued by a school following the course of study outlined by the State superintendent of public instruction, will be admitted to the five-year course without examination. For admission to the four-year course, students must hold diplomas from high schools on an accredited list, or must, in addition to the requirements named above, pass examinations in algebra through quadratic equations, in plane geometry, in elementary physics, and in English. Candidates for admission must bring testimonials of good character, and must be not less than fifteen years of age.

The entrance requirements also presuppose that the applicant has the ability to harness and drive horses, to plow, harrow, mark corn ground, drill, operate the mower, reaper, and farm implements generally, and to perform in a neat and workmanlike manner the details of regular farm work. A failure to pass this examination will not exclude from the college; another opportunity will be provided at the close of the second year to pass on these studies. If the student then fails he will be required to remain at the college during the summer vacation between his second and third years, or to work for the same period on some farm approved by the professor of agriculture. He will receive his final examination on the subject at the beginning of the junior year.

Since both the four-year and the five-year courses cover practically the same ground in agricultural subjects, only the four-year course will be described.

The course is centered around instruction and practice in agriculture and horticulture and the sciences directly bearing upon successful farming. It includes the following credits: Agriculture, 60; agriculture or horticulture (elective), 59; anatomy, 10; bacteriology, 14; bacteriology (elective), 24; botany, 56; botany (elective), 12; chemistry, 42; chemistry (elective), 12; civil engineering, 6; civil engineering (elective), 24; drawing, 10; economics (elective), 12; English, 59; English (elective), 12; entomology, 12; geology (elective), 10; German (elective), 60; history (elective), 12; horticulture, 51; hygiene, 4; mathematics, 29; meteorology (elective), 12; military science and tactics, 22; physics, 20; physics (elective), 12; political science, 10; psychology (elective), 12; sanitary science, 6; veterinary science, 5; veterinary science (elective), 36; zoology, 20; zoology (elective), 12.

Until the end of the first term, junior year, all four-year agricultural students pursue exactly the same studies, but for the remaining five terms they specialize in their technical work, electing either agriculture, including dairying, stock-feeding, soil work, and farm crops, or horticulture, including vegetable culture, pomology, and floriculture.

Instruction in agronomy is given by the professor of agronomy and one assistant in the second and third terms of the freshman year, the first and second terms of the sophomore year, the second and third terms of the junior year, and the first, second, and third terms of the senior year, and is supplemented by instruction in botany, bacteriology, and chemistry.

The courses in botany (aside from those bearing on forestry) for agricultural students include in the freshman year sixty-one hours of structural botany (gross anatomy and morphology of fruits and seeds) and thirty-three hours of systematic botany; in the sophomore year ninety-six hours of plant histology (use of compound microscope, preparation of slides, use of reagents, study of plant anatomy, etc.) and thirty-three hours of ecology; one hundred and twenty-six hours of fungi of economic importance during the first term of the junior year; and forty-eight hours devoted to a study of grasses and weeds during the second term of the junior year. A senior elective in plant physiology has been announced. Instruction in botany is given in the botanical laboratory, a building 55 by 45 feet, two stories with attic and basement. The basement includes a fire-proof room containing the herbarium of about 75,000 specimens, a lavatory, and large work-room for the preparation and storing of specimens and boxes; the first floor contains a dark room, two well-lighted rooms very fairly equipped for histological and physiological studies, and an office and laboratory for the professor in charge; the second floor contains a large room for beginners in botany and for lectures, and a study and laboratory for the assistants; the garret has recently been fitted for use as necessity may require.

Bacteriology is taught by the laboratory method, supplemented by such lectures as are necessary to direct the work. After one preliminary lecture course and two laboratory courses (first, morphological and cultural bacteriology, and second, physiological bacteriology), the student may elect during the winter term of the senior year a laboratory course in bacteriology (ten hours per week) devoted to the biological consideration of the soil. This work is given in a new and well-equipped bacteriological laboratory, which has just been completed at a cost (exclusive of equipment) of \$25,000.

Instruction in chemistry includes general elementary chemistry (ninety-eight hours during the first term of the freshman year), qualitative analysis (one hundred and twenty hours during the second term of the freshman year), organic chemistry (ninety-eight hours during

the first term of the sophomore year), and agricultural chemistry (sixty hours during the second term of the sophomore year and sixty hours, elective, during the second term of the senior year). The course in agricultural chemistry includes the history of agricultural chemistry; the composition of plants, sources of the organic constituents of plants, how to increase their quantity and availability; the soil and the influence of physical agencies on its chemical condition; the nature and action of the ash elements in plant growth; manures and manuring; intensive and extensive agriculture, and conservation of fertility; the chemistry of fodders and stock feeding, of ripening of fruits and grains. The aim in these lectures is to state and solve the chemical problems of the farm. The chemical laboratory building contains a lecture room for 150 students, analytical rooms fitted with evaporating hoods and tables for 68 students, the professor's private laboratory and study, and a suite of rooms for students in metallurgy and quantitative chemical analysis, and is well equipped with chemical apparatus and stores.

The courses in agronomy are introduced by a course of twenty lectures on the formation, character, and distribution of soils; the agencies still at work in soil formation and soil destruction; and the care required to be exercised to preserve the soils of agricultural districts. These lectures are given during the last four weeks of the second term of the freshman year and are illustrated by samples of soil, rock, etc., and by the stereopticon, and are supplemented by laboratory work and oral quizzes. During the third term of the freshman year, ten hours per week are spent in studying soils as regards their characteristics, functions, needs, and treatment in agriculture; drainage, its theory and practice; reasons for the different operations of the farm and the tools used; the planning of farm work, etc. Throughout this work the lantern is used to illustrate the talks and the student is taken to the tool room and to the field for observation. It is the aim to have quizzes at least as often as once per week.

Two hours daily of the first term of the sophomore year are devoted to lectures and laboratory work in agricultural physics, including (besides rural engineering and farm mechanics) laboratory work in the mechanical analysis of soils, the determination of moisture in soils, green and dry fodders, roots and grains, and experiments in moisture and air movements in soils.

The subject of farm crops is given in lectures five hours per week during the second term of the sophomore year. In this course, "good seed and conditions affecting its vitality, general requirements for successful plant growth, conditions governing the time and depth of planting, rate of seeding, etc., and the principles of plant improvement, are discussed. The history, distribution, general characteristics,

adaptability, uses of the several farm crops, and the best method of producing them are studied."

In the second term of the junior year the student may elect "agricultural experimentation." In this course one hour per day is given to lectures and individual work on the part of the student on the experiment station work and literature of this and other countries, the organization and work of the United States Department of Agriculture, methods of experimentation, and the principles underlying the same. Each student is required in closing up the term's work to outline an experiment along some practical line of live stock, dairying, soils, or crops, and to submit the outline to the class for criticism and discussion. The experimentation is continued during the third term two hours per day. For example, the student electing an experi-

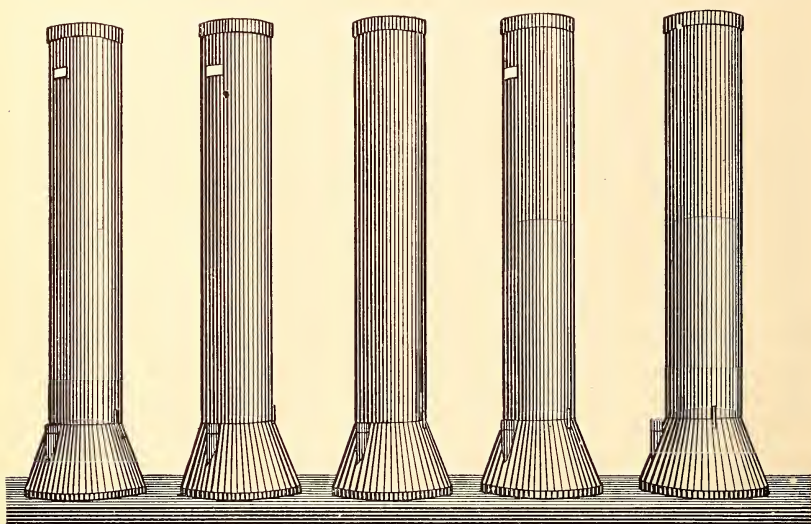
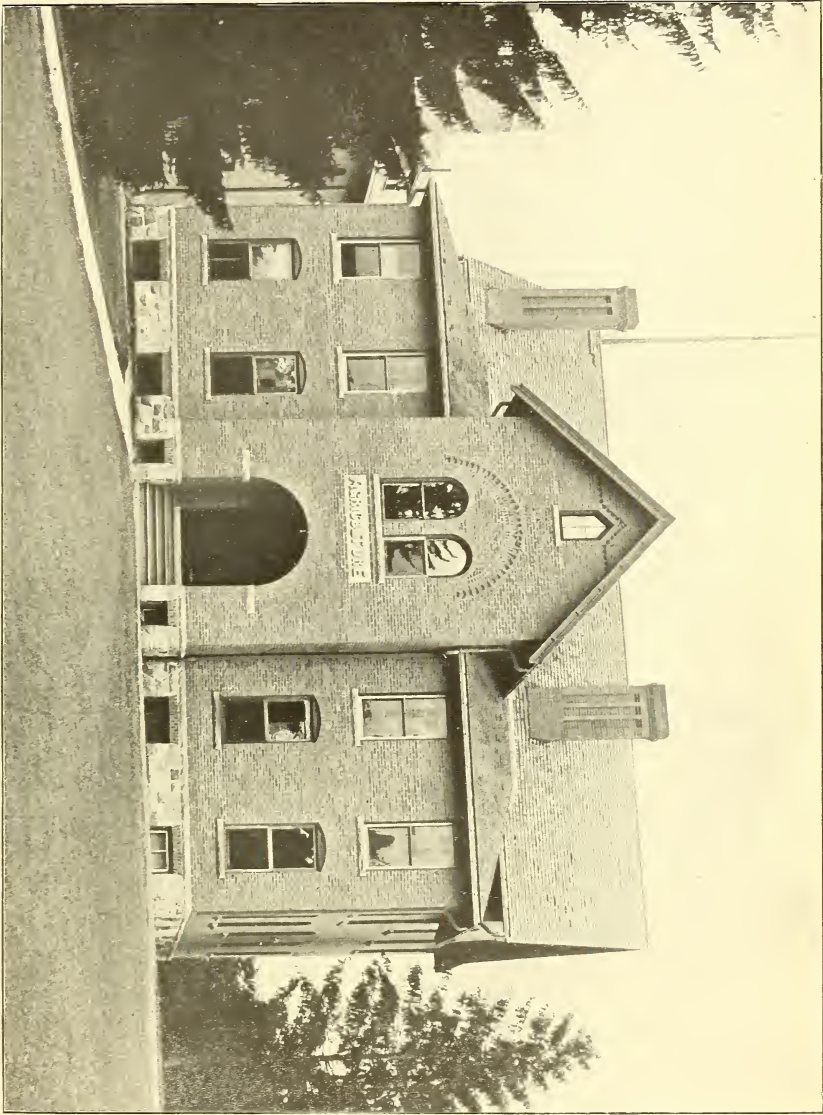


FIG. 2.—Tubes of galvanized iron used to study effectiveness of mulches upon moisture losses.

ment in agronomy, such as tests of forage crop mixtures, variety tests of field crops, fertilizer experiments, etc., is allotted the necessary land, furnished team, implements, seed, etc., and is required to carry through his experiment and report upon it.

"The object of this work is twofold. To the young man going back to the farm it gives a training which enables him at once to pass upon the merits of any line of work described in station literature and to appropriate that portion of it which may be of value to himself; to the young man going into technical fields it gives a training which should give strength and reliability to his work."

In the senior year an elective in soil physics is offered. In this course ten hours per week during the first term are devoted to lectures and laboratory work, embracing a study of the physical properties and



MICHIGAN AGRICULTURAL COLLEGE—AGRICULTURAL HALL.





FIG. 1.—MICHIGAN AGRICULTURAL COLLEGE—STUDENTS MAKING MECHANICAL ANALYSES OF SOILS.



FIG. 2.—MICHIGAN AGRICULTURAL COLLEGE—SOILS LABORATORY AND CLASS ROOM.



characteristics of soils, such as determining the specific gravity, apparent specific gravity, water movements, capillarity, etc. During the winter term ten hours per week are devoted by the student to original investigation work along some line agreed upon between the student and professor in charge. During the spring term ten hours per week, seven weeks, are devoted to advanced work in soils, including lectures, laboratory work, studying soluble salts in soils by the electrical method, the pore space in natural soils, etc.

The building in which the instructional and laboratory work in agronomy is chiefly conducted is built of brick, is 53 feet long, 54 feet wide, and two stories high, with attic and basement, and is known as Agricultural Hall (Pl. V). The basement of this building contains a large laboratory for agricultural physics, a small laboratory for mechanical analysis of soils (Pl. VI, fig. 1), store-rooms, etc., and connects with a small plant house. The first floor contains offices, a dark room, and a large general lecture room provided with 90 square feet of blackboard, two cases of wall maps, a stereopticon, and a 12 by 12 foot lantern screen. The windows of this and other rooms in the building are provided with cloth curtains and wood blinds. The lantern slides at present include illustrations of different phases of soil formation and soil destruction and of different kinds of farm machinery. New slides are being added. The soils laboratory, which also serves as a lecture room, is on the second floor of Agricultural Hall (Pl. VI,

fig. 2) and is supplied with apparatus as follows: Four sets of galvanized iron tubes (fig. 2) for the study of moisture movements in soils and three sets of brass tubes for the study of water and air movements (figs. 3 and 4) in soils; a "King's aspirator" (fig. 3) for determining the effective size of soil grains; a "Whitney's bridge" for determining

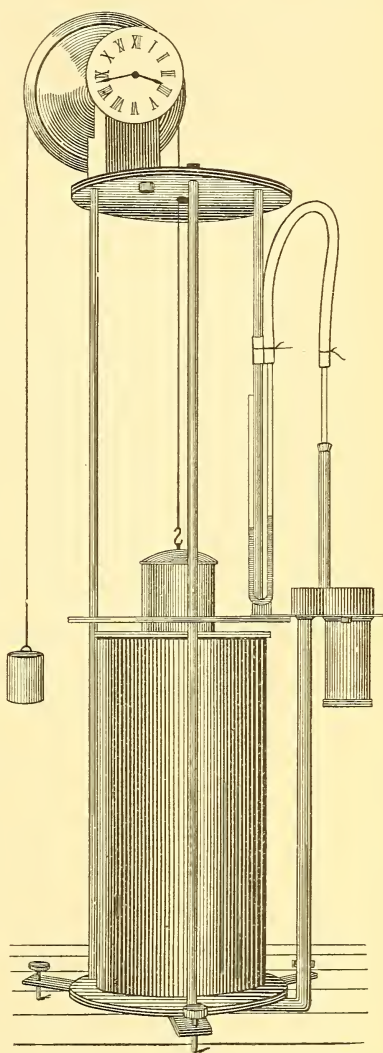


FIG. 3.—King's aspirator to determine the effective size of soil grains.

the soluble salts in soils; apparatus for the mechanical analysis of soils; a steam drying oven and a hot-air drying oven (fig. 6); trays and case, sampling auger, and sampling tube for field work in soils; a torsion balance and a number of other balances; four compound microscopes and one micrometer slide; a number of samples of typical soils from other States, as well as samples of Michigan soils, to which samples additions are being made as rapidly as opportunity permits; a grade level and rod; specific gravity bulbs, drying tubes, and sundry glass and rubber tubing and glassware. The room has about 120 square feet of blackboard.

The college farm comprises over 400 acres, not including the campus, orchards, gardens, stock yards, and the experiment station plats. It is divided into twenty pasture, field, and wood lots. At present the several acreages are about as follows: Woods, 140; wild pasture, 30; tame pasture, 37; hay, 69; and roots, cereals, and forage crops, 141 acres. The soil is a drift soil and ranges from a sandy soil to a fine clay soil, all of which is interspersed with coarse gravel and hard heads and boulders. The farm machinery is up to date in every particular and includes a large collection of modern types of implements and machines, as well as some of the older types, which are used by the students in making comparisons of draft, work, effect on soils, etc.

The library contains over 21,000 bound volumes and about 5,000 pamphlets, and is rich in scientific works. The tables of the reading room are supplied with all the leading agricultural papers and journals. In matters concerning crops and soils reference is made, first of all, probably, to station literature, then to Storer's Agriculture, King's works, and others of Bailey's Rural Science Series, and the Rothamsted reports.

#### EXHIBIT No. 5.

### A FEW OF THE PRACTICUMS IN AGRONOMY.

#### *The movement of air through different soils.*

*Description of apparatus.*—The apparatus used for the study of air movements through soils consists of an aspirator, as shown in fig. 4, and 12 brass tubes 16 inches in height and having a diameter of 3 inches. These soil tubes are all filled to the depth of 1 inch with a coarse sand, and above the sand are filled to a depth of 12 inches with the different soils indicated in the table. By means of apparatus prepared for the purpose the soils are introduced into the tubes and packed so that any difference in the pore space in the soils must be due to the physical properties of the soil. It will be seen that the variation of size of soil grain, variation in the proportions of large and small grains, variation in amount of organic matter present, etc., must be the factors resulting in the differences in the rates at which the air moves through the soil.

Observe that we have not the conditions in the soil in the cylinders that we have in the soil in the field, and that with this apparatus we are studying only the effects resulting largely from the properties named.

*Details of the practicum.—*

1. With the rubber tube detached from soil tubes, lift the aspirator weight, allowing bell to fall to bottom of aspirator tank.
2. Attach rubber tube to soil tube No. 1.
3. Now carefully lower weight until it is just sustained by pressure of air upon the bell.
4. With watch note time required for the hand to pass over three divisions of the dial, recording time as indicated in a table like the one below.
5. In like manner attach rubber tube to Nos. 2, 3, 4, 5, 6, 7, and 8 and note and record the time required to pass over three divisions of the dial.

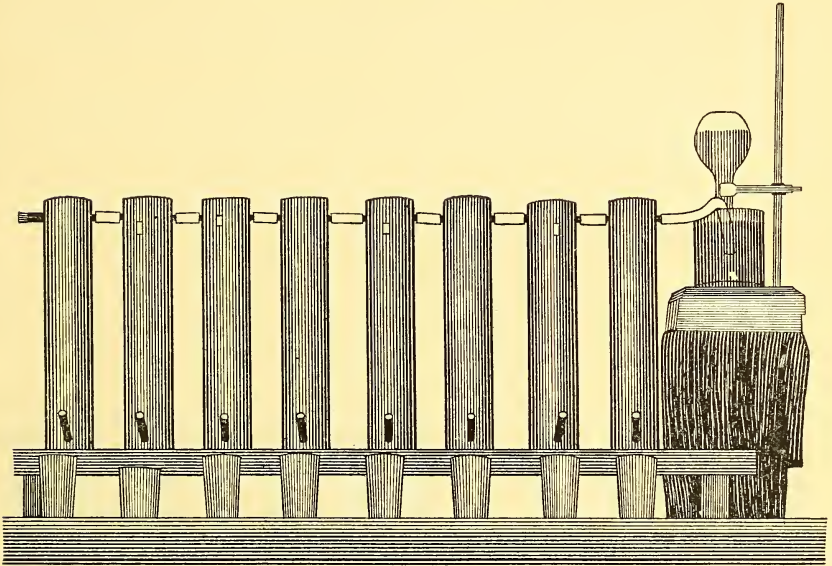


FIG. 4.—Apparatus used to study the movement of air through soils.

6. In like manner attach rubber tube to Nos. 9, 10, 11, and 12 and note the time required for the hand to pass over one division on the dial. Multiply this time by three and introduce in table.

7. Make computations and fill in as indicated in the table.

Soil.	Number of cylinder.	Time.				Relative rate of air movement.
		Initial.	Final.	Net.	Average.	
Sand .....	1	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....
Sand, with 3 per cent lime .....	3	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....
Peat .....	5	.....	.....	.....	.....	.....
	6	.....	.....	.....	.....	.....
Clay loam.....	7	.....	.....	.....	.....	.....
	8	.....	.....	.....	.....	.....
Clay, with 3 per cent lime.....	9	.....	.....	.....	.....	.....
	10	.....	.....	.....	.....	.....
Clay .....	11	.....	.....	.....	.....	.....
	12	.....	.....	.....	.....	.....

*Percolation of water through different soils.*

*Description of apparatus.*—This apparatus (fig. 5), consists of soil tubes similar to those used for the study of the rate of air movement through soils differing only in having tubes at the top by which the series may be connected by pieces of rubber tubing and supplied automatically with water so that the head or pressure in all the tubes can be kept constant. The tubes are filled in the same manner with soil as for studying air movements, and the rate of percolation depends upon the same physical properties of the soils as in the case of the movement of air.

*Details of the practicum.*—

1. See that the water supply is properly arranged.\*
2. Tare the glass or cylinder of each soil tube and record its weight in the proper place in a table like the one shown below, but do not return them immediately under the drain tubes.
3. Remove corks from drain tubes and insert wire drips.
4. When water drops from all the wires, place the glasses and cylinders quickly under the drain tubes, noting the time.

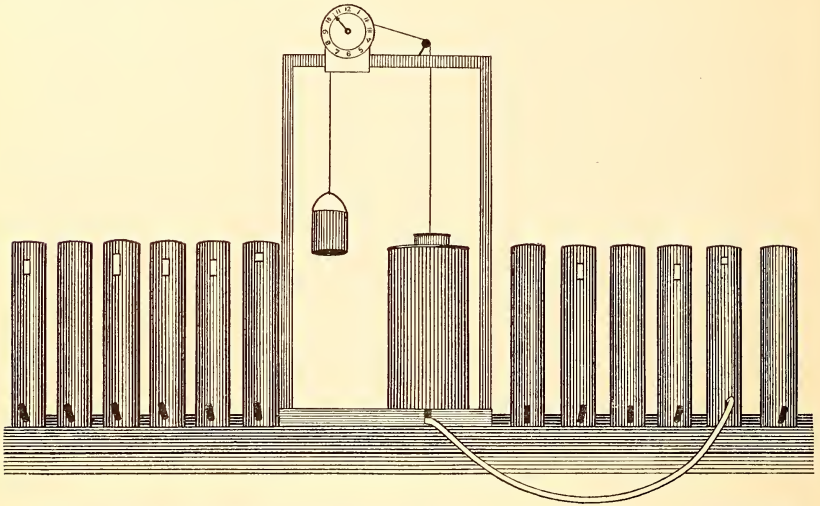


FIG. 5.—Apparatus used to study percolation of water through soils.

5. At the end of 45 minutes quickly remove glasses and cylinders.
6. Remove wire drips and insert corks in drain tubes.
7. Weigh glasses and cylinders with contents and record weights in the proper place in the table.
8. Make proper computations and introduce results in table.

Soil.	Number of cylinder.	Weight of empty cylinder.	Weight of cylinder and contents.	Weight of water percolating in 45 minutes.	Average percolation in 45 minutes.	Relative rates of percolation.	Tons per acre per hour percolating.	Inches per hour percolating.
Clay .....	{ .....	.....	.....	.....	}	.....	.....	.....
Clay loam .....	{ .....	.....	.....	.....				
Sandy .....	{ .....	.....	.....	.....				
Peat .....	{ .....	.....	.....	.....				

*Determination of soil moisture.*

## IN SOILS FREE FROM STONE.

To take samples:

1. Provide yourself with soil tube, mallet, and three soil trays.
2. Having determined place for taking soil sample, pack the surface of the soil lightly with the foot. Press or drive the tube into the ground until the 1-foot mark on the tube is even with the surface of the ground. Give the tube a turn. Place one hand firmly over the top of the soil tube to keep out air and with the other hand grasp and slowly withdraw the tube.
3. Remove cover from one of the trays, invert the soil tube, and allow the core to pass from the tube into the tray. Put cover on tray at once.
4. Return soil tube to the hole and press or drive down until the 2-foot mark on the tube is even with the surface of the ground. Remove as before and place the core in a second tray.
5. In like manner secure core from third foot and introduce into a third tray.
6. Pass to another point and as before secure cores of the first, second, and third foot, respectively, and introduce the cores into the trays containing the first, second, and third foot, respectively, already obtained.
7. Repeat until composite samples of four are obtained.

To dry samples:

8. Weigh each tray with contents, recording weights of each. Remove covers and place trays in drying oven.
9. After forty-eight hours replace covers and weigh trays with contents, carefully recording weights. Be sure samples are dry.
10. Remove the dry soil from trays, wipe the trays carefully and weigh, recording weight.
11. Determine (*a*) loss of moisture from the soil, (*b*) weight of dry soil, and (*c*) the per cent of moisture in each soil estimated on dry weight of soil.

## IN ROCKY SOIL.

To take samples:

1. Provide yourself with two soil trays and a spade.
2. Having determined place to take samples dig a hole 1 foot deep and a little wider and longer than the width of your spade. See that one side is perpendicular. Remove all loose soil from bottom of hole.
3. With spade cut off a slice 1 inch thick from the perpendicular side of the hole to a depth of 6 inches, allowing soil to fall to the bottom of the hole where it should be quickly crumbled and mixed and freed from stones larger than a small marble.
4. Place about one-half pint of this soil in one of the trays and cover. Remove the rest of the soil from the bottom of the hole.
5. With spade finish cutting the slice to the depth of 1 foot and proceed as above to mix and free from stone.
6. Place one-half pint of this soil in the second tray and cover.
7. Selecting another point proceed as above to take samples of the first and second 6 inches, respectively, and place the samples so taken in the trays with the samples of the first and second 6 inches already taken, respectively.

To dry the samples:

8. Weigh each tray with contents, recording weights of each. Remove covers and place tray in drying oven.
9. After forty-eight hours replace covers and weigh trays with contents, carefully recording weights. Be sure samples are dry.
10. Remove the dry soil from trays, wipe the trays carefully and weigh, recording weight.
11. Determine (*a*) loss of moisture from soil, (*b*) weight of dry soil, and (*c*) the per cent of moisture in each soil estimated on dry weight of soil.

*Determination of moisture in green crops, fodders, roots, and grains.*

## I.—PREPARATION.

(a) Green crops. Cut sample close to ground. Either fold or tie into short bundles or cut into short lengths and put into a tray.

(b) Fodder (including hay and straw). Cut a quantity of the material in a feed cutter or with a knife, mix well, and fill tray with sample.

(c) Roots. Select one or more typical roots, clean with a good brush or wash and wipe carefully. With a sharp knife slice in tray quickly and cover.

(d) Grain. Place about one pint of cleaned grain in a tray. If it is desired to determine the moisture of corn in the ear select a typical ear having all of its kernels and place in tray.

## II.—LABELING.

For the material placed in the trays it is sufficient to record the number of the tray.

Upon those materials not placed in trays a tag bearing your name should be placed.

## III.—WEIGHTS.

You will need to determine: (a) Net weight before drying; (b) Net weight after drying; (c) Loss of moisture by drying.

With this data determine the per cent of moisture in the undried material.

## IV.—THE DRYING.

Place material in hot-air oven (fig. 6) having temperature of  $120^{\circ}$  C. Drying should continue until materials have reached constant weights. This will usually be accomplished in twenty-four hours, but sometimes as much as forty-eight hours are required.

[Each student is given from six to eight materials to dry. In some cases he is required to go to the bin or field to procure them.]

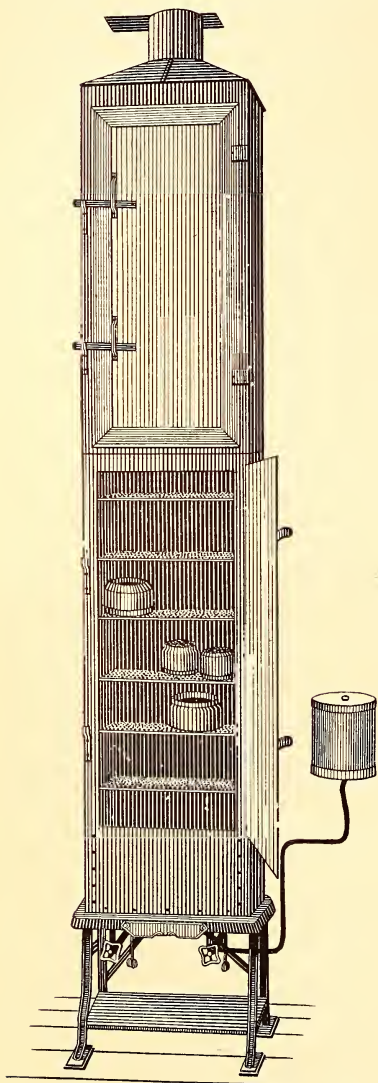


FIG. 6.—Hot-air drying oven.

**EXAMINATION QUESTIONS IN SOILS AND CROPS.**

[This set of questions covers in a general way the work done during the spring term of the freshman year.]

1. What is meant by tillage? What are the chief objects sought in tillage? Tell quite fully how one of these objects is accomplished.
2. Explain the action of the common American plow. How does it differ from the English plow? Speak briefly of their relative merits. What objections to the common plow? What may we do toward obviating some of the bad effects?
3. Why do we cultivate? Describe an ideal cultivator and ideal cultivation.
4. What are some of the methods for removing the surplus water from land?
5. What will govern each of the following: Depth of drain, distance apart of drains, size of tile to be used.
6. What grade should tile drains have, what is the least grade allowable, and what precaution should be taken in laying a drain at such a grade?
7. How should laterals be connected with drains? Where and how should silt wells be constructed?
8. What is meant by rotation of crops? Why do we rotate at all?
9. Outline what you would call a good rotation, and give reason for the presence of each crop in the rotation.
10. When would you apply barn manure? At what rate, and why?
11. Speak of the value of clover as a crop. Why is it difficult to grow clover in Michigan? Tell how you would secure a stand of clover.
12. The effect of lime upon soils? Why? Would you apply lime to the soils of Michigan? If yes, at what rate and why? If no, why not?
13. What difference between a good truck soil and a good grass soil, and why is each soil especially adapted to its own crop?
14. In what way is the size of soil grain related to (a) the water holding capacity of the soil, (b) the plant feeding qualities, and (c) to the retaining of plant foods against percolation?
15. How does the amount of moisture required to grow a crop compare (a) with our annual rainfall, (b) with the water content of our soils in the month of March? What objections to summer fallowing?

**COLLEGE OF AGRICULTURE OF THE UNIVERSITY OF MINNESOTA.**

Candidates for admission to the College of Agriculture of the University of Minnesota must have the equivalent of either a three-year course in the school of agriculture plus one year of work of high-school grade in algebra, geometry, English, history, and economics, or a four-year course in a city high school plus one or two years in the school of agriculture. The school of agriculture is a technical high school, in which agriculture and subjects closely related to it largely predominate. These subjects include agricultural botany, chemistry and physics, dairy chemistry, agronomy, farm accounts, animal husbandry, dairy husbandry, fruit growing, vegetable gardening, etc., presented in a way to fit young men for successful farm life or for entrance to the college of agriculture.

The college course in agriculture is designed for those graduates of the school of agriculture and students from other institutions equally well prepared who desire

further instruction in practical agricultural science, in the sciences related to agriculture, and in literature and the arts. Since all students who enter this course have had the technical, scientific, and general work offered in the school of agriculture, the college course includes only advanced work of a collegiate grade. This course designs to efficiently prepare students for either farm life or for the work of the agricultural specialist. It emphasizes the importance of plant and animal production and the upbuilding of rural homes and farm life, while the biological and physical sciences are made prominent.

Following the four years of preparation in practical agricultural lines in the school of agriculture, the freshman and sophomore years are devoted largely to the study of the sciences. The technical subjects relating to agriculture and household economics are mainly offered as electives in the junior and senior years, when the freedom for election enables the student to choose as a specialty a major science or an agricultural or a household subject around which to group related elective subjects. The elective courses during the last two years give an opportunity for further culture in literary and philosophical lines and for becoming more proficient in scientific research work in some of the many problems pressing for solution in the development of the State and national agricultural experiment stations. The instruction in the various technical agricultural and household divisions in the college course is for the most part a continuation of the work in these subjects in the school of agriculture, each subject being treated from a more technical standpoint. Students who have first graduated from the agricultural school are ready in their junior and senior years to elect specialties for study and research work along lines in which they hope to work after graduation.

The subjects in the school of agriculture which more especially prepare for the collegiate work in agronomy are agricultural chemistry, agricultural botany, agricultural physics, and the subjects included under the title of agriculture.

Agricultural chemistry is divided into dairy chemistry; chemistry of foods, soils, and fertilizers, and domestic chemistry. Under the title of soils and fertilizers the student receives instruction in the composition of soils and their properties, the sources of plant food, the kinds and amounts of foods required by crops and the best ways of supplying these demands, the various forms in which plant food exists in the soil, farm manures, their uses and action upon the soil, the income and outgo of fertility from the farm, soil exhaustion and soil improvement, the rotation of crops, as based upon the chemistry of soils and the principles governing the conservation of the fertility of the soil. Laboratory practice forms an important feature of all the work in agricultural chemistry.

Agricultural botany is taught with special reference to its bearing upon the everyday problems that present themselves to the farmer and the gardener. By means of flowers and plants from the greenhouse and nursery, studied under the simple and the compound microscope, students are given a clear idea of the general principles of plant structure and vegetable physiology.

In agricultural physics the general principles of physics are taught, special stress being laid upon those principles which to the greatest extent enter into the business of the farmer. About half of the time

is devoted to experimental work which includes capillarity of soil; diffusion and osmosis of gases and liquids; heating, lighting, and ventilation; farm machinery, in particular pumps, eveners, pulleys, milk testers, centrifugals, incubators, windmills, steam and gasoline engines; friction and lubricants; tensile strength of wire and binding twine of different grades; lightning and lightning protection.

The work designated "agriculture" in the school of agriculture includes (1) "introductory agriculture—soils; selecting and planting farms; subduing the fields; drainage; irrigation; fences; roads; buildings; water supply; groves and introductory lessons concerning farm business, farm life, and the relations of general science to agriculture;" and (2) field crops and farm management, comprising instruction in remodeling farm plans, production and management of farm manures, rotation and handling of field crops, care and use of pastures and meadows, weeds and their destruction, and the laws of heredity and variation in plant breeding, together with instruction in methods of breeding the leading field crops.

The college course in agronomy includes soil physics, field crops and seed, and plant breeding. Instruction in soil physics is given in the divisions of agricultural physics and agricultural chemistry, while that in field crops and seed and in plant breeding is given mainly by the professor of agriculture.

Under the head of field crops and seed are considered the botany, cultivation, use and place in the rotation of the various cereal, forage, root, fiber, sugar, and miscellaneous crops. Special attention is given to the subjects of permanent, rotation, annual, and shift pastures and to soiling crops; to permanent and rotation meadows, and to the production and preservation of all kinds of dry-cured and ensiled fodders. A thesis on one or more field crops is required of each student.

The work in plant breeding includes instruction on such subjects as heredity, variation, science of breeding, breeding as an art, improvement by nature and under scientific experimentation, securing foundation stocks, value of very large numbers, immense value of the occasional individual which can transmit qualities of peculiar value, use of an ideal, use and misuse of the score card, intrinsic qualities, fancy points and distinguishing marks, pedigree records of prepotency, fundamental principles underlying the arrangement of the record books, bibliography and terminology, study of the literature of breeding. Attention is also given to the botany of the reproductive organs of field crops, field-crop nursery management, producing new qualities by hybridizing and by change of environment, hybridizing versus cross-breeding, in-breeding and self-fertilization, originating varieties and improving standard varieties, methods of disseminating new varieties, seed and plant introduction, experimentation in the theories relating

to heredity, variation and practical breeding, seed growing as a farm business, seed merchandising.

Elective practicums give opportunity to gain practical experience, to acquire greater manual dexterity in doing farm work, to secure practice in conducting experiments, and to gain experience in teaching agricultural subjects.

Agronomy is taught in dairy hall (Pl. VII, fig. 1) in temporary quarters which include one good recitation room, offices, and laboratory room. There is also a seed-breeding laboratory which furnishes facilities for special instruction in field seeds and in laboratory work in plant breeding. The college possesses a stereopticon with several hundred lantern slides, including illustrations of crops, implements, machinery, processes of drainage, etc.; imported models of wheat and of clover flowers and seeds; many charts of root systems and illustrations of floral organs which have been drawn at this institution; also maps and designs of farm plans, both for laying out new farms and for reorganizing old ones. Several hundred pasteboard boxes 24 inches long, 13 inches wide and 5 inches high, such as tailors use for suit boxes, are annually filled with bundles of weeds, grasses, and forage crops. These serve in the classes for material to tear apart, examine the seeds, and get acquainted with the general appearance. Seeds are also preserved in bottles. The collection of farm machinery in use at the university farm is supplemented by collections on exhibition at the State fair grounds, adjoining the farm, and at warehouses in St. Paul and Minneapolis.

One unique feature of the office equipment is a special index filing case. Here are collected newspaper clippings, manuscripts, and references to literature in the library. These are put on sheets,  $5\frac{1}{2}$  by  $8\frac{1}{2}$  inches, separated by division cards, and arranged under a scheme similar to that used by the Office of Experiment Stations in classifying special index cards of the station literature. This filing case now contains much material and is referred to constantly by students in the college course in writing essays and theses in connection with their class work. Each student who writes a thesis on a farm crop or other subject is required to furnish a copy for this filing case, and to include any bibliography he has been able to collect on that subject. Thus the students are assisting in building up the contents of this filing case and it is recognized by them as very valuable.

No text-books are as yet in use, instruction being given almost entirely by lectures. The agricultural library now contains 6,000 books and about 6,000 pamphlets, including reports and bulletins. Aside from the large number of pamphlets and other publications of the different agricultural institutions and societies, a large number of the more important technical and agricultural magazines are kept on file, bringing together all the agricultural literature of any importance.

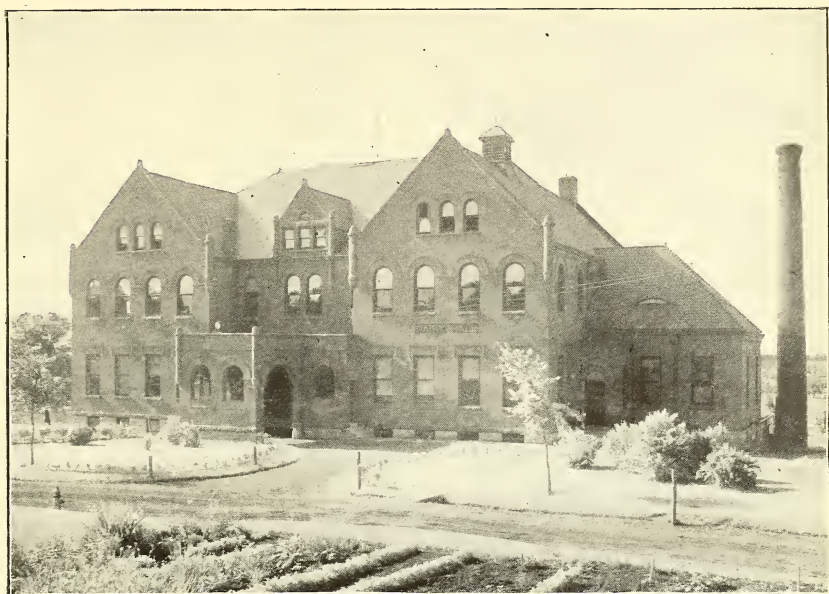


FIG. 1.—UNIVERSITY OF MINNESOTA—DAIRY HALL.



FIG. 2.—UNIVERSITY OF MINNESOTA—EMASCULATING AND CROSS POLLINATING WHEAT.





FIG. 1.—UNIVERSITY OF MINNESOTA—CENTGENER THRASHING MACHINE AND FANNING-MILL SEPARATOR IN USE IN THE FIELD CROP NURSERY.

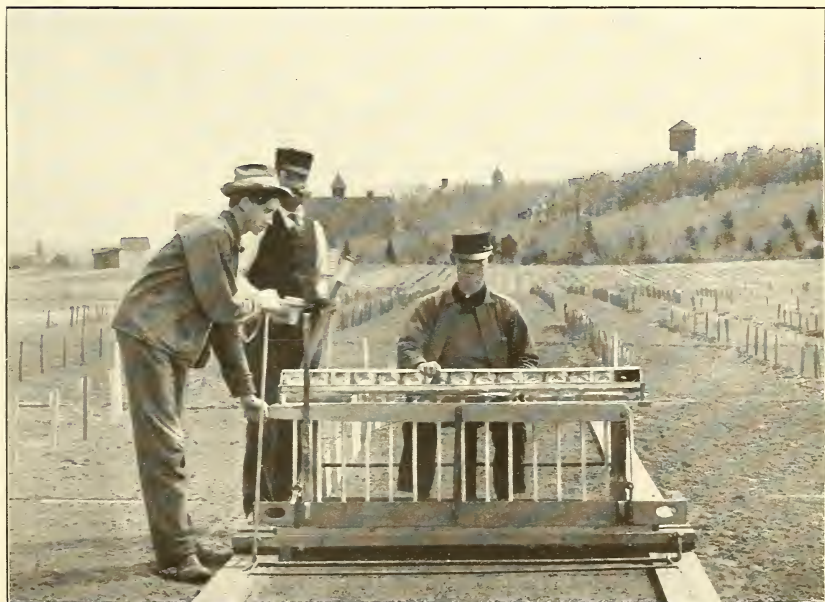


FIG. 2.—UNIVERSITY OF MINNESOTA—MACHINE FOR PLANTING GRAIN IN NURSERY BEDS.



The university farm contains 250 acres of land, of which about 150 acres are devoted to experiment station and college of agriculture work. The soil is a mixture of clay and sand, and is well adapted to the various uses to which it is put. On the portion of the farm used by the college and station there are many experiments in farm management, rotation of crops, treatment of pastures, improvement of crops by breeding (Pl. VII, fig. 2), etc. In the plant breeding experiments there are annually planted nearly 300,000 individual plants, including grains, clovers, root crops, etc., and for much of this work special machinery has been devised (fig. 7 and Pl. VIII, figs. 1 and 2).

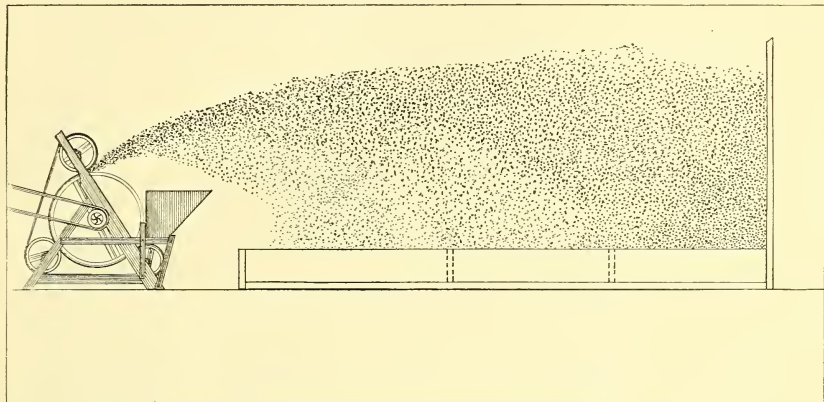


FIG. 7.—Centrifugal seed-grading machine.

Students who make a specialty of agronomy assist in these experiments. Farms in the vicinity serve as a basis for designing farm plans and working out problems in farm management.

#### THE UNIVERSITY OF NEBRASKA.

The industrial college of the University of Nebraska offers several four-year agricultural groups (courses) leading to the degree of bachelor of science—a technical group, a general group, and two special groups. The technical group is intended for graduates of the three-year course in the school of agriculture. “The studies in the general groups are arranged to meet the needs and requirements of those students whose primary object is a broad and general education.” Those in the special groups are for students “fitting themselves to be instructors in agricultural subjects or to be experiment-station workers,” and “have been planned and coordinated to enable students to direct their work so as to meet their individual needs and preferences.” Candidates for admission to the general and special groups must present certificates from accredited schools, academies, or colleges, or must pass examinations (1) on the following required subjects: English, four years of language (ancient or modern or both), algebra through

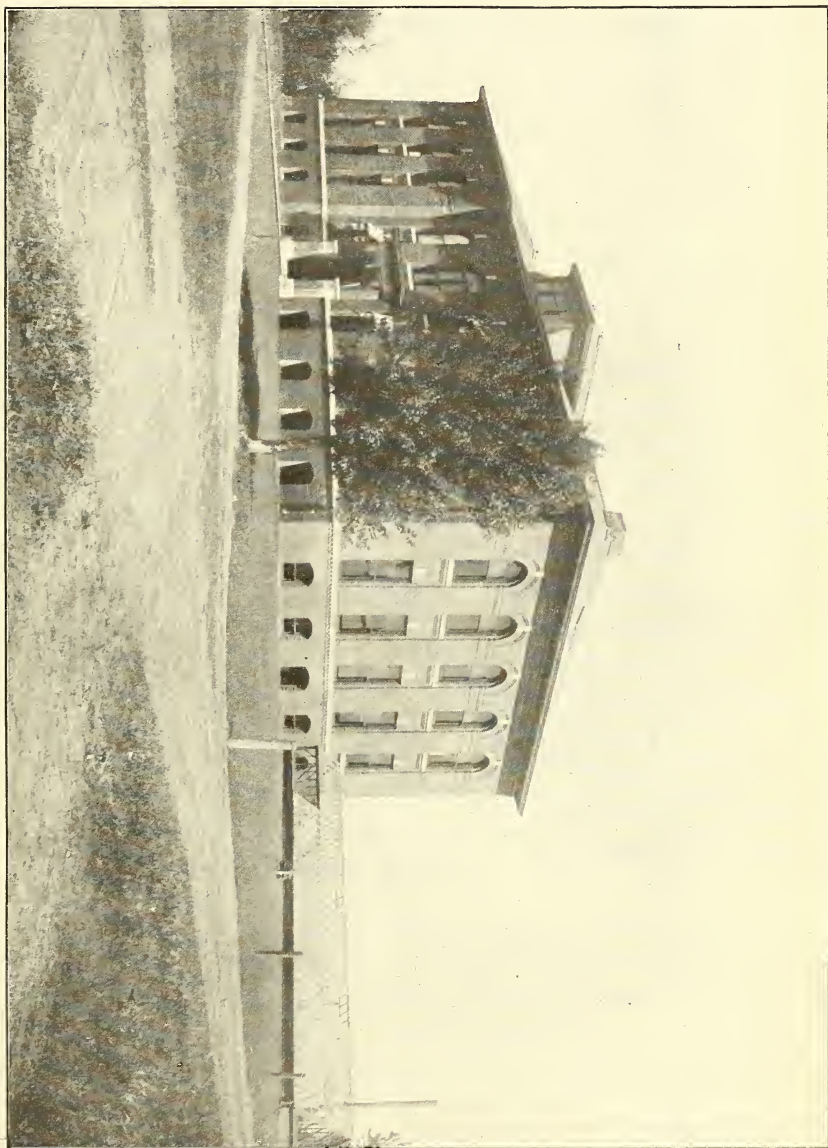
logarithms, plane and solid geometry, and elementary botany, chemistry, and physics; and (2) on a sufficient number of the following subjects for a total of 11 credits: Language, history, manual training, physical science, natural science, plane trigonometry, mechanical drawing, physiology and hygiene, physiography, civics, and political economy.

"All the courses in the first year of residence are prescribed, and form the common bases of both the general and the special groups offered." The courses included in this year and the number of hours per week for each course are mathematics 5, modern language 4, physics 3, English 2, chemistry 2, military drill 1. The work in chemistry includes "a careful study of the occurrence, methods of preparation, and properties of the common elements and their chief compounds." After the first year the courses are mostly elective. At least 40 per cent of the work of the last three years is taken in agriculture and chemistry or agriculture and botany, but "no student shall take or receive credit for more than forty hours' work in any department during his undergraduate course."

Agronomy at the University of Nebraska "includes on the instructional side the subjects of soils, field crops, farm management, and the care and use of farm machinery." The course in soils includes the following: The origin, deposition, and natural transportation of soils; physical and chemical constitution of soils and subsoils; influence of the size of soil grains on the rate of solution of plant food, drainage, aeration, water storage, capillarity, etc.; forms in which water exists in soils; movement of water in the soil; soil temperatures; evaporation of water from the soil; methods of soil treatment for conservation of soil moisture; the significance of a chemical analysis of soil; fixation of fertilizing materials; nitrification; availability of plant food; tillage, reasons for tillage, effect of drifting, effect of plowing wet or dry soil; subsoil plowing, water-holding power of loose and compact soils; disking, listing, etc.; the application of barnyard and green manures and commercial fertilizers. Given by the professor of agriculture.

This is followed by "field crops, their general composition and their relation to the air and soil; useful and essential ingredients of the ash of plants; functions of the ash constituents of plants and the formation of plant substance; functions of the roots, stems, and leaves of plants; the breeding of cereals; a treatment of each of the principal field crops, somewhat according to the following scheme: Characteristics, varieties, vitality, climate, soil, manures, tillage, seeding, cultivation, harvesting, preservation, position in rotation, uses. Given by the professor of agriculture."

Following these two courses is a laboratory course in the "Properties of soils," continuing throughout the year and given by the professor of agriculture and the instructor in agriculture.



UNIVERSITY OF NEBRASKA—AGRICULTURAL BUILDING.





FIG. 1.—UNIVERSITY OF NEBRASKA—FIELD CROPS LABORATORY, STUDENTS JUDGING SEED CORN.



FIG. 2.—UNIVERSITY OF NEBRASKA—SOILS LABORATORY.



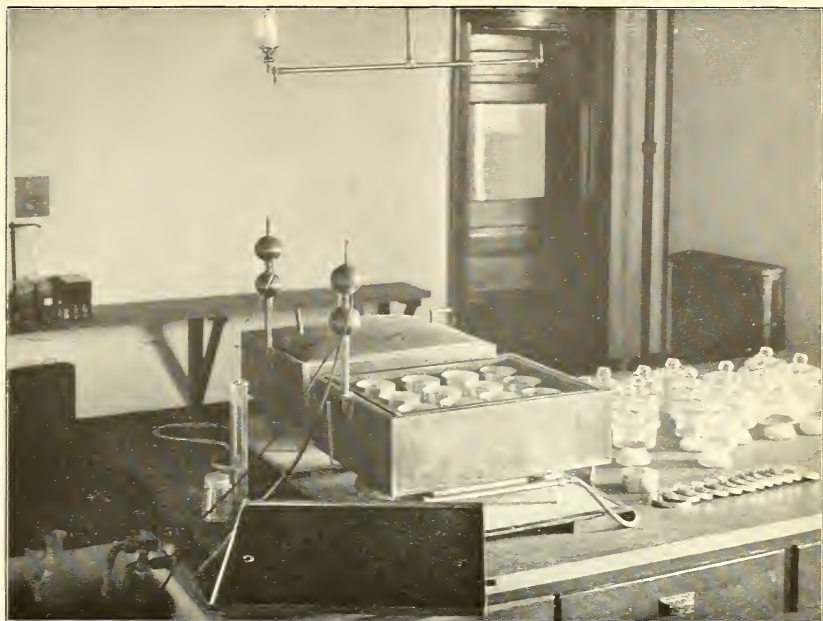


FIG. 1.—UNIVERSITY OF NEBRASKA—APPARATUS FOR MAKING DETERMINATIONS OF SOIL MOISTURE.

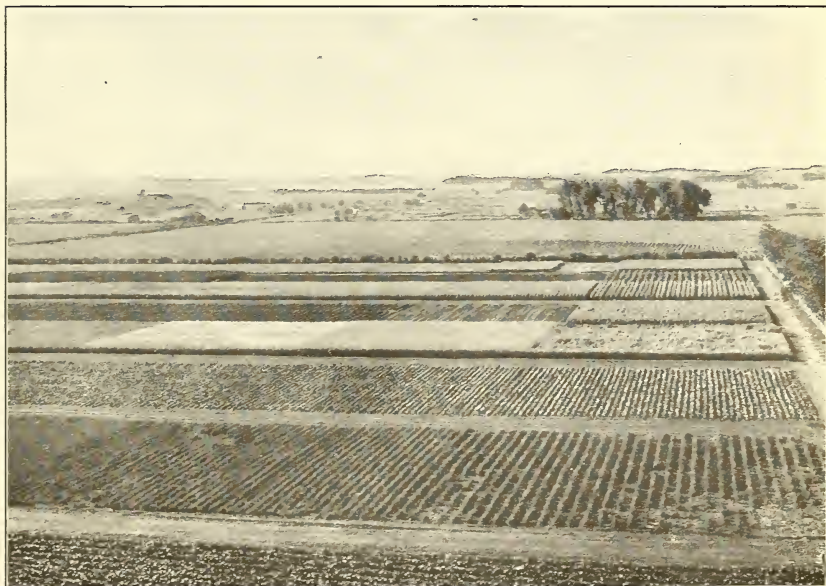


FIG. 2.—UNIVERSITY OF NEBRASKA—EXPERIMENT PLATS.





FIG. 1.—UNIVERSITY OF NEBRASKA—SEED LABORATORY.



FIG. 2.—UNIVERSITY OF NEBRASKA—CORNER IN THE SEED STOREROOM.



Elective courses are offered as follows:

“Methods of investigation with soils. A study in detail of reported experiments, the object being to familiarize the student with the methods of scientific investigation in the subject under discussion.

“Methods of investigation with field crops. Conducted similarly to the above.

“Plant food in the soil; a series of pot experiments.

“Production and movement of crops as affecting prices.

“Sugar-beet culture. History of the culture of the sugar beet. Effect upon general agriculture of sugar-beet culture. Varieties of the sugar beet. Types. Composition and structure of the beet plant. Soils and climatic conditions adapted to raising sugar beets. Preparation of the soil. Planting the seed. Cultivation. Harvesting. Siloing. Seed production; breeding, establishing of strain. Position of the beet crop in the system of crop rotation.

“The laboratory work [in soils] consists of the following demonstrations: Determination of specific gravity of soils; determination of the volume weight of soils; power of loose soils to retain moisture; the power of compact soils to retain moisture; rate of percolation of water through soils; rate of percolation of air through soils; effect of mulches on evaporation of water from soils; behavior of the soil toward gases; capillary attraction of the soil; the power of soils to fix ammonia.”

Instruction for students in these courses is by means of lectures and laboratory practice, using books of reference throughout almost the entire course. In the study of field crops the experiment station publications are used very freely. Students fitting themselves to be instructors in agricultural subjects or to be experiment station workers are given every opportunity to study the methods of agricultural investigations at the agricultural experiment station farm.

Class rooms and laboratories used for instruction in agronomy are in the general agricultural building (Pl. IX). One class room, 33 by 20 feet (Pl. X, fig. 1), contains specimens of plants, seeds, etc., used for purposes of instruction in field crops. One laboratory, 33 by 20 feet (Pl. X, fig. 2), is used for demonstrations of various properties of soils.

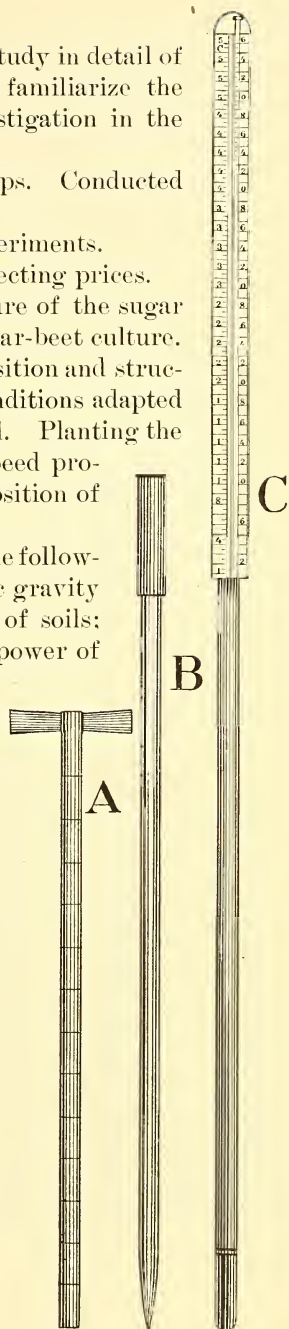


FIG. 8.—Movable soil thermometer: A, hollow steel tube,  $\frac{1}{2}$  inch internal diameter, 15 inches long; B, solid steel plunger, 19 inches long, which closely fits the tube A; C, long stem (18 inches) thermometer which closely fits the tube A.

This laboratory is provided with desks, water, gas, etc., and may be considered a well-equipped laboratory. The desks are  $3\frac{1}{4}$  feet high and 4 feet wide, with drawers and cupboards on both sides and water and gas cocks in the center. The apparatus is designed to record soil temperatures (fig. 8), to take samples of soils (fig. 9), to determine soil moisture (Pl. XI, fig. 1), and to test a number of properties of different soils, for instance, the water-holding power of loose and compact soils, the rate of percolation of air through soils, and certain other physical properties, some of the apparatus for which was designed by Professor Gibbs, formerly of the Ohio State University.

About 50 acres of land are used for purposes of instruction, although other land used for experi-

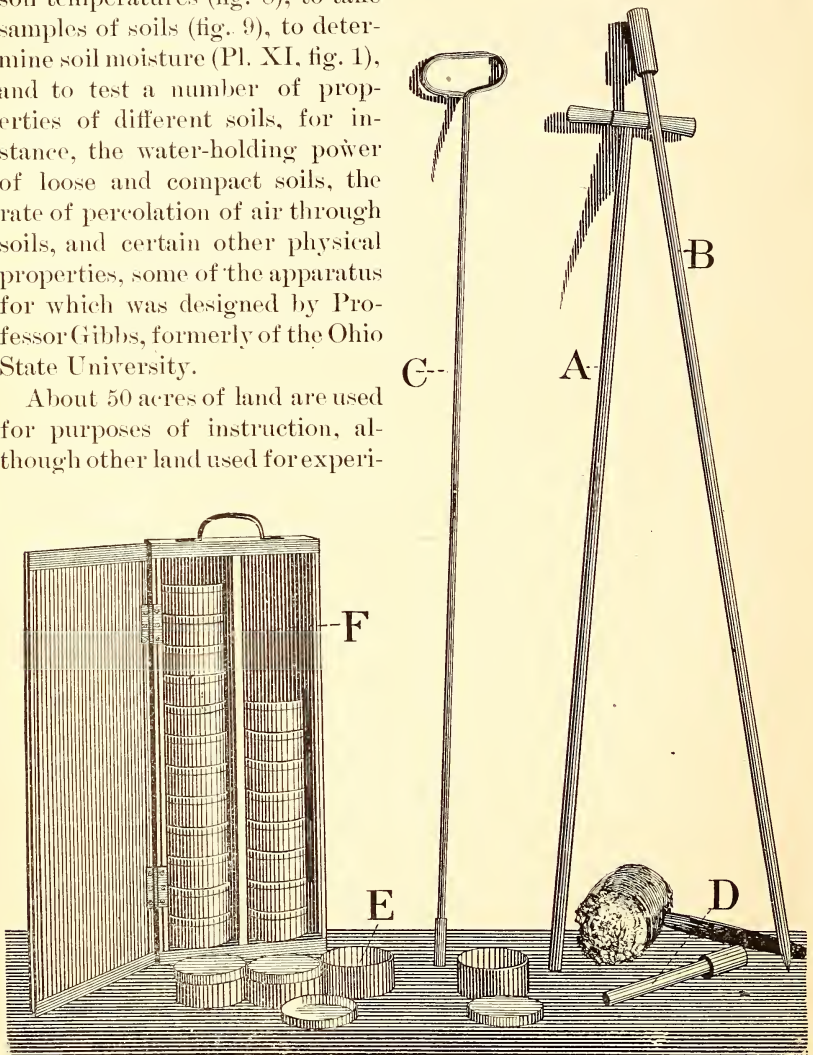


FIG. 9.—Soil-sampling apparatus: A, hollow steel sampling tube,  $\frac{7}{8}$  inch internal diameter, 45 inches long, marked every 3 inches; B, solid steel rod,  $46\frac{1}{2}$  inches long, which closely fits A; C, ejector; D, driving head for sampling tube; E, aluminum cans for soil samples; F, case for sample cans.

mentation may also be considered as a part of the instructional equipment (Pl. XI, fig. 2). Forty acres are divided into subfields of exactly 5 acres each. These fields are not fenced, but are divided by roadways, the land occupied by which is not a part of the 5-acre tracts,

The roadways are 1 rod wide. Four of the subfields are severally in rotations, intended to demonstrate the effect of manuring and of periodically seeding to grass. For instance, subfields C and H are each year planted to the same crops and the same character of manure applied in equal quantities, the only difference being that at certain intervals subfield H is allowed to lie in grass for a period of years, while subfield C is cropped continuously. The following is the rotation:

	Subfield C.	Subfield H.
1898.....	Corn (manured) .....	<i>Bromus inermis.</i>
1899.....	Corn.....	<i>Bromus inermis.</i>
1900.....	Oats.....	<i>Bromus inermis.</i>
1901.....	Winter wheat.....	<i>Bromus inermis.</i>
1902.....	Corn (manured in winter).....	Corn (top-dressing of manure before plowing up <i>Bromus inermis</i> ).
1903.....	Oats.....	Oats.
1904.....	Winter wheat.....	Winter wheat.
1905.....	Corn (manured in winter).....	Corn (manured in winter).

Subfields D and I are in similar rotations, except that subfield D does not receive any manure and that the crops grown on these fields are not the same as those on the other two subfields during the same year. The remainder of the subfields are used for growing new and not generally grown crops or for particularly good varieties or strains of varieties of common crops. In another field are 10 acres divided into plats of one-fifth acre, and each of these is planted to a particular perennial forage plant or combination of such plants. These are mostly grasses and clovers. They serve as an object lesson in profitable seeding to pastures and meadows in this region. Hurdles of special size are provided for fencing these, so that any one of them may be pastured when desired. In this manner the pasturage value is demonstrated. There is also a field of about 10 acres divided into experiment plats of one-tenth acre each. These, although primarily for experimentation, are also of value for purposes of instruction.

For instruction in implements and machinery, there are walking, riding, and disk plows; breaking plows; disk, spike, acme, and spring-tooth harrows; subsurface packer; roller; subsoilers; press drills; lister; corn planter; mowers; rake; hay loader; hay tedder; binder; thrashing machine, etc. There are, for instruction in soils, samples of soils from nearly a hundred different localities in the State. These have been analyzed mechanically and the original soil and its constituent parts arranged in small vials on a card showing the percentage of the various sized particles. There is a collection of about 90 of the native grasses in the State and some 200 specimens of grains (Pl. XII, figs. 1 and 2).

The college classes in soils use Snyder's Chemistry of Soils and Fertilizers, but the course is given largely by means of lectures. In field crops frequent use is made of Farmers' Bulletins and State agricultural society reports, and of Morrow and Hunt's Soils and Crops of

the Farm. The principal books of reference for classes in soils are Le Conte's Elements of Geology, Warington's Chemical and Physical Properties of Soils, Wahnschaffe's Scientific Examination of Soils, Johnson's How Crops Feed, Storer's Agriculture, and Roberts's Fertility of the Land; for classes in field crops, the publications of the various experiment stations and of the United States Department of Agriculture.

The agricultural library contains complete or nearly complete sets of the Annals of Agriculture, Journal of the Royal Agricultural Society of England, Transactions of the Highland and Agricultural Society of Scotland, Quarterly Journal of Agriculture, Journal of Agriculture, Journal für Landwirtschaft, Centralblatt für Agricultur-chemie, Forschungen auf dem Gebiete der Agricultur-Physik, an almost complete set of the publications of the various State experiment stations, and a fairly complete set of the publications of the United States Department of Agriculture. There is also a fairly complete collection of text-books and other books dealing with agriculture in a general or special way, besides files of the more important agricultural newspapers. Altogether, in that section of the library pertaining to agronomy there are upward of 1,500 volumes.

#### OHIO STATE UNIVERSITY.

The four-year course in agriculture leading to the degree of bachelor of science in agriculture is given in the College of Agriculture and Domestic Science of the Ohio State University. This course is designed not only to make specially trained agriculturists, but also educated men. The course presupposes that a young man has had a high school training or its equivalent, and that he has had the training in farm matters that necessarily comes to a young man who has lived on a farm. It supplements this training, but does not displace it. About one-third of the time of the student during the four years is or may be devoted to language (English or foreign), history, and economics; about one-third to pure science, and one-third to technical or professional training. Electives in the senior year allow for some variation in this regard.

Applicants for admission to this course must be at least 16 years of age and have graduated at a State normal school, or approved high or preparatory school, or have passed examinations in the following subjects: English grammar, composition and rhetoric, English classics; arithmetic, algebra, plane geometry; descriptive and physical geography, elementary botany, and physics; civil government or general history; and Latin (grammar and four books of Cæsar), or French (grammar and simple reading and translating), or German (grammar and reading, not less than 300 pages).

The course in agronomy is given during the third or junior year of

the college course and is preceded by instruction in agricultural chemistry (during the first and second years), physiological and economic botany and vegetable pathology (during the first year), and horticulture (during the second year).

In chemistry the course includes lectures and laboratory work on the principles of chemistry and chemical nomenclature, organic chemistry, and the application of chemistry to agriculture. The latter is given during the third term of the first year and includes the following topics: Ingredients of plants, organic and inorganic, essential and non-essential; sources of plant food, air, and soil; nature of soil, mechanical portion, nutritive portion, assimilable, and reserve plant food; soil exhaustion and amelioration; barnyard manure, its sources, composition, and preservation; commercial fertilizers, their rational use and methods of determining the needs of soils. In the second year there are lectures and laboratory work on the industries related to agriculture (e. g., manufacture of sugar, starch, vinegar, and liquors); and the analysis of fertilizers, feeding stuffs, dairy products, sugar and sugar producing plants, fruits and vegetables, water, soils, oils, fats, grains, etc. The lecture rooms and laboratories are thoroughly equipped with apparatus and chemicals for the use of instructors and students.

The course in botany includes elementary, physiological, and economic botany, and vegetable pathology, with lectures and recitations three times a week and laboratory and field work twice a week. In economic botany the student receives instruction and practice in handling the microscope and has the opportunity of learning much of the important modern methods in technique. The main part of the course in vegetable pathology is devoted to a study of the parasitic fungi most destructive to cultivated plants, and the means of their prevention forms the last part of the course. Instruction in botany is given in the botanical building which contains a large lecture room, museum, herbarium, three laboratory rooms, dark room, drying room, storeroom, and offices. The lecture room will, the coming year, contain a stereopticon furnished with electric light; a large number of charts, many of them colored lithographic photographs and mounted illustrative specimens are the principal appliances for daily class work. In this room are placed fifteen of the more important popular journals of botany for the use of students. The botanical books in the university library, a valuable and growing collection, are largely used for reference in connection with the several courses. The museum contains a large amount of illustrative material, the native medicinal plants and the collection of Ohio woods being very complete. The State herbarium consists of between 12,000 and 15,000 sheets of Ohio plants. The general herbarium is about the same size. Professor Kellerman's private herbarium of 20,000 specimens, mostly parasitic

fungi, is also used by the department. The large laboratory is well equipped with dissecting and compound microscopes; also the usual appliances for doing both elementary and advanced histological work. One of the small laboratories is devoted to experimental work in vegetable physiology and the other to systematic botany. The greenhouse attached to the botanical building is an important adjunct to the department. There are four sections containing a total of nearly 3,000 feet of glass. It contains a large number of illustrative plants, perhaps 3,000 specimens, representing the principal plant families and belonging to several hundred species. The greenhouse furnishes much fresh material for laboratory use. It is also used as a laboratory to carry on special work when growing plants are used.

The courses in agronomy are given by the professor of agriculture and the instructor in agronomy and include two elementary courses during the second and third terms of the junior year and two advanced elective courses during the first and second terms of the senior year. The courses in the order in which they must be taken are as follows:

*Elementary course in soils.*—Lectures and recitations three times a week upon the origin, formation, kinds, and physical properties of soils and their improvement by cultivation, fertilization, drainage, and irrigation. Practicum once a week in laboratory, testing physical properties of several soils; determining the relation of soils to heat, moisture, air, and fertilizers, and making mechanical analyses. For a detailed description of the laboratory exercises in this course, see Exhibit No. 7, page 59.

*Elementary course in farm crops.*—Lectures and recitations three times a week upon the history, production, marketing, cultivation, and harvesting of farm crops. For a list of examination questions indicating the scope of this work, see Exhibit No. 9, page 70. Practicum once a week with growing and dried specimens of farm crops, including grasses, clovers, and other forage crops. A list of laboratory or field practicums in this course is given in Exhibit No. 10, page 71.

*Advanced course in soils.*—Lectures and recitations once a week on the physical properties of soils; the relation of soils to heat, air, and moisture; the effect of fertilizers on soil structure and fertility; consideration of practical methods of tillage as affecting crop producing power of the soil. Laboratory and field experiments during two two-hour periods each week. A detailed schedule of laboratory work in this course is given in Exhibit No. 8, page 69.

*Advanced course in farm crops.*—Lectures and recitations once a week on (a) the effect of climate, soil, and markets on the distribution and adaptation of farm crops in the United States; (b) the best method of crop production, including a careful study of the details of field

OHIO STATE UNIVERSITY—TOWNSHEND HALL.





experimentation as set forth in experiment station bulletins and reports and the publications of the United States Department of Agriculture; (c) the consumption of farm crops. Practicums twice a week.

Instruction in these courses is given largely by means of lectures, but frequent use is made of such text-books as *The Soil and the Physics of Agriculture*, by King; and *Soils and Crops of the Farm*, by Morrow and Hunt; and of bulletins, monographs, and reports issued by the experiment stations and Departments of the United States Government.

Instruction in agronomy, as in other branches of agriculture, is given in the university building known as Townshend Hall, which was completed in 1898 at a cost of \$100,000.

Townshend Hall (Pl. XIII) is 260 feet long, and varies in width from 64 to 78 feet. It contains two stories and a basement which is 14 feet high, making the building practically three stories high. The walls above the basement line are of gray pressed brick. The basement walls and the front entrance are of Bedford, Ind., Oolitic limestone, and the trimmings are of terra cotta of the same color as the brick. The roof is of dark-red tile. The building is of slow-burning construction throughout, with painted interior brick walls, exposed beams, maple floors, and hard pine finish. The lecture rooms and laboratory for the course in agronomy are on the first floor of this building.

The soil physics laboratory is supplied with apparatus for studying the specific gravity of soils; volume weight of soils; power of loose soil to retain moisture; power of compact soil to retain moisture; rate of flow of air through soils; rate of percolation of water through soils; effect of mulches on evaporation of water from soils; effect of cultivation on evaporation of water from soils; power of dry soil to absorb moisture from the air; and the capillary rise of water through soils. Mechanical analyses are also made of typical soils.

In the study of soils, the large glass house with its equipment of railroad tracks, trucks, and pots affords opportunity for the student to test the adaptability of crops to various soils; the fertilizer requirements of soils and to experiment on various other problems of crop growth.

In the study of crops, large use is made of the collection of dried specimens of grasses, grains, and seeds. The grass garden contains about 25 varieties of grasses and clovers growing side by side where comparisons may be made as to the value of each for pasture, meadow, and grass. The farm is visited frequently by students who make observations and studies of the practical methods there employed in the growing of crops.

#### EXHIBIT No. 7.

#### LABORATORY WORK IN THE ELEMENTARY COURSE IN SOILS.

Experiments are arranged with reference to the number of laboratory periods in the term, and since there are ten to twelve periods, 12 experiments have been planned which are described on the following pages. The experiments are designed with special reference to the practical demonstration of some of the important principles underlying soil physics, and to supplement class-room teaching with actual work with the soil itself.

The following soils used in the experiments are typical agricultural

soils selected on the Ohio State University farm with reference to their differences in texture and crop producing power:

No. 1. Muck soil. Selected from a very fertile cornfield.

No. 2. First bottom alluvial loam. Very fertile.

No. 3. Second bottom sandy loam with considerable clay.

No. 4. Fine sand (0.25 millimeter to 0.1 millimeter in diameter).

No. 5. Coarse sand (0.5 millimeter to 0.25 millimeter in diameter).

The soils are brought from the fields and air-dried in the laboratory. Numbers 1 to 3 are sifted through a 2-millimeter sieve having circular holes, and numbers 4 and 5 through finer sieves. The soils are then placed in numbered bins in the laboratory.

The following is a list of the laboratory experiments with descriptions and illustrations of each:

*Experiment No. 1.*

DETERMINATION OF SPECIFIC GRAVITY OF SOILS.

This experiment shows weights of the various soils as compared with the weights of equal volumes of water. The specific gravity of most soils is about 2.5—that is, soil calculated free of air space weighs 2.5 times as much as an equal volume of

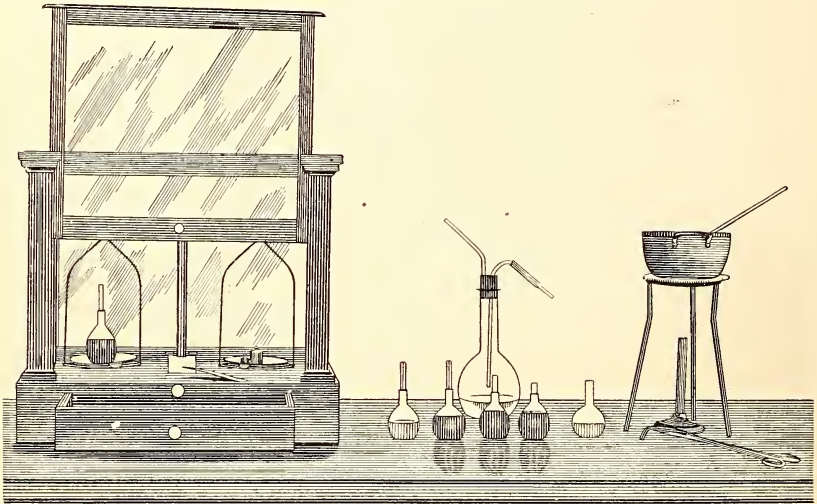


FIG. 10.—Apparatus for determining specific gravity of soils.

water. The more organic matter a soil contains the less its specific gravity. In general, the specific gravity of a soil decreases inversely as its content of organic matter. Specific gravity must not be confused with apparent specific gravity, which will be explained in experiment No. 2.

With a flask of 50 cubic centimeters capacity and provided with a ground-glass stopper, drawn out to an open capillary tube (fig. 10), determine specific gravity of four soils which will be provided—Nos. 1, 2, 3, and 4.

Fill flask with distilled water so that no air bubbles appear after the ground-glass stopper is inserted. Note temperature of water in flask. Wipe flask dry and weigh.

Pour out about one-half of the water in the flask and put in a weighed quantity (10 grams) of the soil, which has been previously dried at  $110^{\circ}$  C. for twenty-four hours. Place the flask in a shallow water bath and boil for two minutes in order to drive out the soil air. Fill the flask with distilled water and bring to the same temperature at which the previous weight was taken. Weigh. (See that flask is full when weight is taken.)

*Calculation.*—Add weight of soil used to weight of flask filled with water and deduct therefrom weight of flask filled with water and soil. The difference expresses the weight of a volume of water equal to the quantity of soil used.

The specific gravity is found by dividing the weight of the soil taken by the weight of the water it has displaced.

### *Experiment No. 2.*

#### DETERMINATION OF THE VOLUME WEIGHT, APPARENT SPECIFIC GRAVITY, AND POROSITY OF SOILS.

Determine the volume weight of four soils, Nos. 1, 2, 3, and 4. Weigh the empty tubes (fig. 11) carefully. Use the soil direct from the bins and pour into the tube the measure level full. Then place the tube in the compacting machine (fig. 12) and

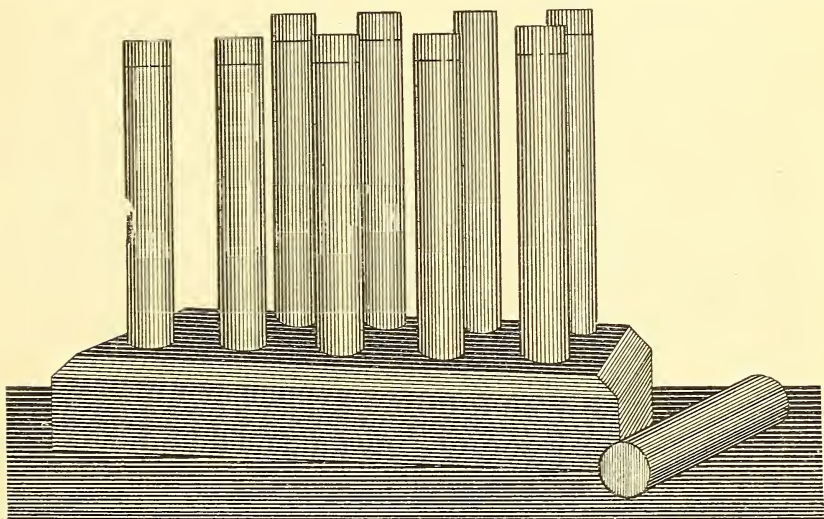


FIG. 11.—Determination of volume weight, apparent specific gravity, and porosity of soils.

allow the weight to fall six times from the 12-inch mark. Pour in another measure of soil and repeat. Continue this until the tube is filled to the mark near the top. Weigh. Determine at the same time with a special sample the hygroscopic water which escapes at  $110^{\circ}$  C. Also determine the number of cubic inches, or centimeters, occupied by the soil in each tube.

*Calculations.*—Subtract the weight of the empty tube plus the weight of hygroscopic water in the soil used from the weight of the filled tube. This will be the weight of the given volume of soil. The volume weight of a cubic centimeter of soil should then be calculated.

By dividing the volume weight of the soil with the weight of the same volume of water, the apparent specific gravity of the soil is obtained.

By dividing this apparent specific gravity with the real specific gravity of the soil obtained in experiment No. 1, and subtracting from 100, the remainder expresses

the per cent of porosity of the soil, i. e., the space which, in the dry soil, is occupied by air.

The volume weight of a soil varies with the amount of packing. A freshly plowed soil is much lighter per cubic foot than the same soil packed by rains or by tramping.

In other words, soil has an apparent and a real specific gravity. Average field soils in good tilth have an apparent specific gravity of about 1.2, and when entirely free from air, a real specific gravity of about 2.5.

The compacting machine referred to above was designed to pack all the soils into the tubes uniformly and thus eliminate, in a large degree, the error due to unequal packing in different tubes when making comparisons of apparent specific gravity of different soils. The machine does not do the work with absolute exactness, but seems to be a decided improvement over the uncertain method of filling by hand, which at best gives very unsatisfactory results.

### *Experiment No. 3.*

#### THE POWER OF LOOSE SOILS TO RETAIN MOISTURE.

Use soils Nos. 2, 3, 4, and 5 in this experiment. Place disks of damp cheese cloth in the bottom of the tubes (fig. 13) and then weigh the tubes carefully on the torsion balance. Fill the tubes up to the mark, 1 inch from the top, by pouring the soil in gently, leaving the soil in the tubes in a very loose condition, with much air space throughout the mass. Weigh the filled tubes. Place the filled tubes in the empty galvanized iron box. Pour water in the box until the water level almost reaches the tops of the tubes, thus allowing the water to percolate up through the soils. When the water level in the tubes comes up to the level of the water in the box remove the tubes and place them in the frame, where the water is allowed to percolate out of them. Glass plates should be placed over the tops of the tubes to prevent evaporation. The tubes should be weighed from day to day until the minimum weight is reached—until percolation ceases.

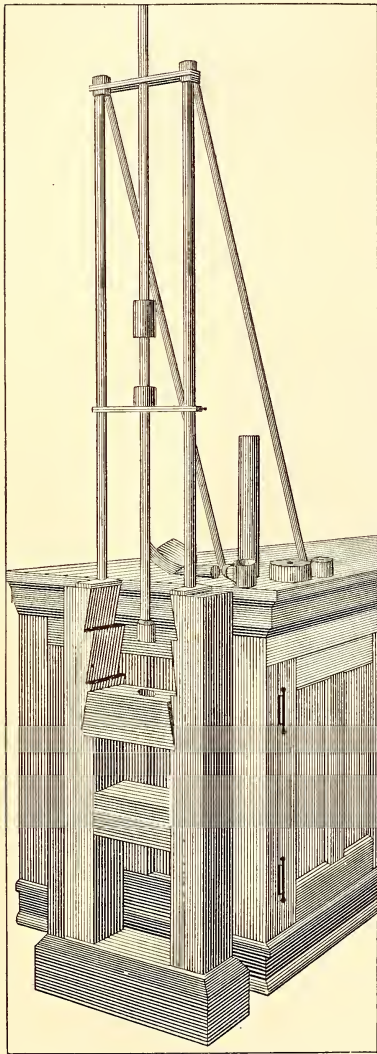


FIG. 12.—Soil-compacting machine.

The difference in weight between the tubes filled with dry soil and the wet soil will be the amount of water retained by the loose soil. In order to get the total water content of the wet soil, it is necessary to add to this the weight of hygroscopic water which the dry soil contained. The hygroscopic water of the dry soil should be determined with a special sample taken at the time the tubes are filled.

Calculate the total number of pounds of water retained per cubic foot of dry soil and also the number of surface inches of water it represents.

This experiment illustrates the power of different types of loose soil to retain water. One of the advantages of cultivating soil is to make it loose in structure so that rain will be absorbed and retained more thoroughly than would be the case if the soil were uncultivated. Study results from this experiment in connection with those of experiment No. 4 for compact soil.

#### *Experiment No. 4.*

##### THE POWER OF COMPACT SOILS TO RETAIN MOISTURE.

Use soils Nos. 2, 3, 4, and 5 in this experiment. Place disks of moist cheese cloth in the bottom of the tubes (fig. 13). Weigh and then fill within 1 inch of the top in the following manner: Pour in 1 measure of soil. Place cylinder in compacting machine and drop weight six times from the 12-inch mark. Pour in another measure and repeat. Continue this until cylinder is filled within 1 inch of the top.

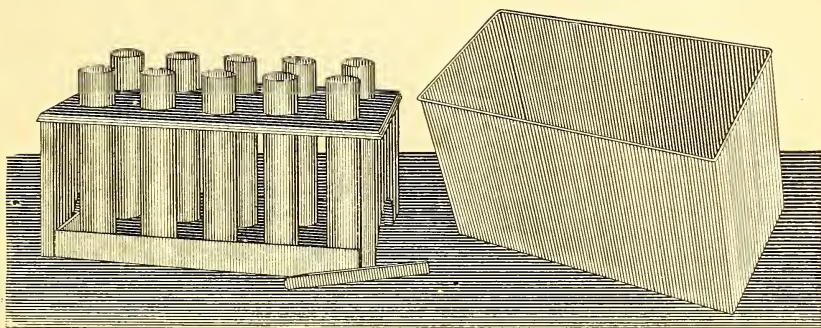


FIG. 13.—Determining the power of soils to retain moisture.

Place the filled tubes in the empty galvanzied iron box. Pour water in the box until the water level almost reaches the tops of the tubes, thus allowing the water to percolate up through the soils. When the water level in the tubes comes up to the level of the water in the box remove the tubes and place them in the frame where the water is allowed to percolate out of them. Glass plates should be placed over the tops of the tubes to prevent evaporation. The tubes should be weighed from day to day until the minimum weight is reached—until percolation ceases.

The difference in weight between the tubes filled with dry soil and the wet soil will be the amount of water retained by the compact soil. In order to get the total water content of the wet soil it will be necessary to add to this the weight of hygroscopic water which the dry soil contained. The hygroscopic water of the dry soil should be determined with a special sample at the time the tubes are filled.

Calculate the total number of pounds of water retained per cubic foot of dry soil and also the number of surface inches of water it represents.

This experiment illustrates the power of different types of compact soil to retain water.

The results of this experiment should be studied in connection with those of experiment No. 3.

*Experiment No. 5.*

## RATE OF PERCOLATION OF WATER THROUGH SOILS.

The series of tubes (fig. 14) having been filled within 1 inch of the overflow pipes with soils Nos. 1, 2, 3, 4, and 5, the compacting machine is used.

After each measure of soil was put in the weight is dropped twice from the 6-inch mark. The surface of the soil in each tube is covered with 1 inch of coarse gravel to prevent the soil being disturbed by flowing water.

See that all tubes are connected by rubber tubing and the extreme ends of small tubes corked.

Pour in distilled water gently and keep the cylinders almost level full. After the flow into the glass flasks has become uniform, note the number of cubic centimeters which flow through in half an hour. Determine this by measuring in a graduated cylinder.

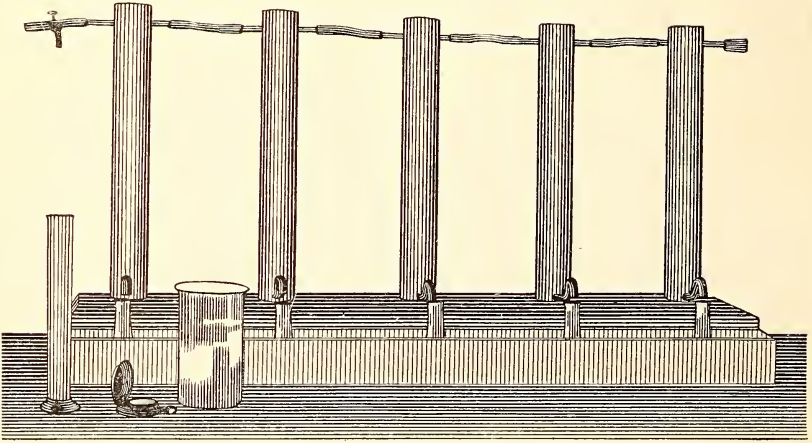


FIG. 14.—Rate of percolation of water through soils.

The character of soils used may be examined in the boxes in the laboratory. The tubes are numbered to correspond with the soil numbers.

This experiment brings out the differences between soils in regard to the rate of percolation of water through them. Other things equal, it is desirable that a soil should allow water to pass through slowly, holding moisture the greatest length of time within the reach of crop roots.

*Experiment No. 6.*

## RATE OF FLOW OF AIR THROUGH SOILS.

Soils Nos. 1, 2, 3, 4, and 5 are used in this experiment. The cylinder numbers correspond with the soil numbers.

The compacting machine was used in filling the cylinders (fig. 15). After each measure of soil, the weight was dropped three times from the 12-inch mark.

Open the cock on the copper cylinder and detach the hook holding the weights. Allow the copper cylinder to sink by its own weight. Attach the rubber tube to soil tube No. 1. Attach the weight hook and note the number of degrees passed by the pointer in 10 minutes or a longer time, if it be necessary in case of the fine-grained soils. Record the weight for each of the five soils, calculating the weight per hour.

This experiment has a direct practical bearing on the question of soil ventilation. Soil air is essential to the life of nitrifying and other bacteria which develop fertility. Other things equal, the more readily soil will allow air to circulate through it, the more favorable conditions will be for the formation of plant food.

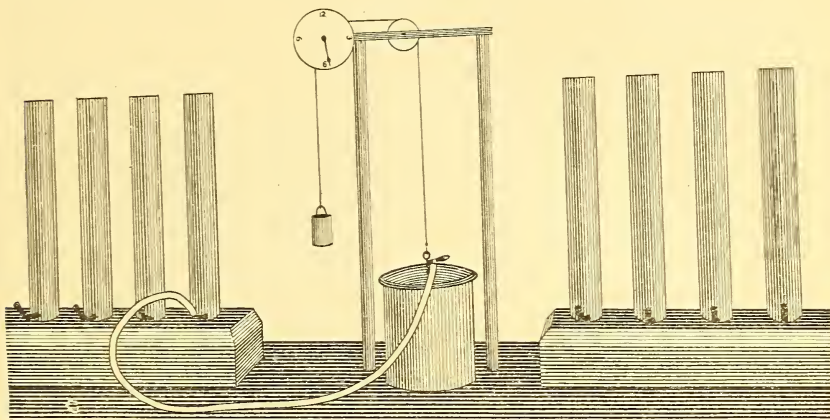


FIG. 15.—Apparatus to determine the rate of flow of air through soils.

### *Experiment No. 7.*

#### EFFECT OF MULCHES ON EVAPORATION OF WATER FROM SOILS.

The cylinders (fig. 16) are 18 inches deep by 4 inches in diameter, and are filled with first bottom soil from the Ohio State University farm. The compacting

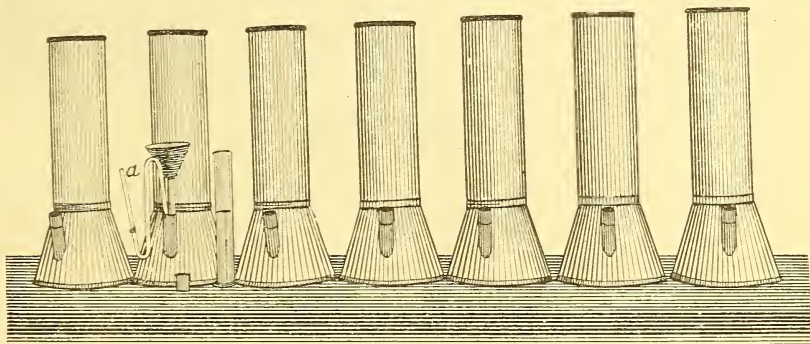


FIG. 16.—Soil tubes for showing the effect of mulches on evaporation of water from soils.

machine was used in filling the cylinders to insure comparatively uniform compactness of soil in all cylinders.

No. 1. Not mulched.

No. 2. Not mulched.

No. 3. Surface cultivated 2 inches deep. (Soil mulch).

No. 4. Surface cultivated 2 inches deep. (Soil mulch).

No. 5. Mulched with 2 inches of coarse gravel.

No. 6. Mulched with 2 inches of fine sand.

No. 7. Mulched with 2 inches of sawdust.

No. 8. Mulched with 2 inches of cut straw.

No. 9. Not mulched. (Placed in draft).

No. 10. Not mulched. (Placed in draft).

Fill the cylinders to the same level with distilled water every twenty-four hours for one week and keep a careful record of the amount of water used each day. The "S" glass tube (*a*, fig. 16) will be used to determine the exact level to which the tubes should be filled.

The cylinder which evaporated the least water during the period of observation should be the one having the most effective mulch.

In recording results show the amount of water put in each cylinder daily, and also the total amount for each cylinder for the entire run of the experiment.

### *Experiment No. 8.*

#### THE POWER OF AIR-DRY SOIL TO ABSORB MOISTURE FROM THE AIR.

Use soils Nos. 1, 2, 3, and 4 in this experiment. Place 400 grams of air-dry soil from the bin in a shallow zinc tray (fig. 17), spreading it out as uniformly as possible.

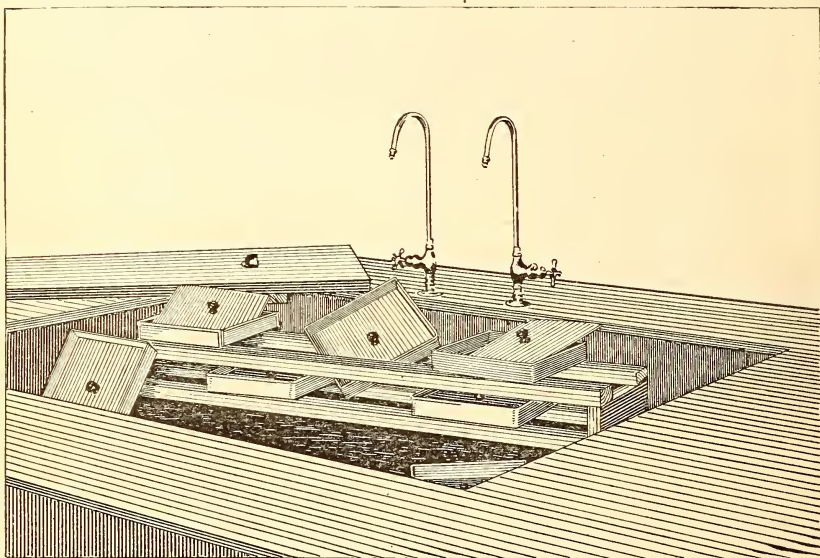


FIG. 17.—Determining the power of air-dry soils to absorb moisture from the air.

After weighing the tray (lid on) with the soil, place an empty weighed box, together with the others (lids off), upon a shelf in the pneumatic trough. Place a thermometer in the trough and at each weighing read the temperature. Weigh each box (lid on) every twenty-four hours and deduct the increase in weight of the empty box from the increase in weight of each of the other boxes. Repeat the weighings every twenty-four hours until with the same conditions of temperature an approximately constant weight is obtained. The moisture retained is calculated for 100 grams of the soil dried at  $110^{\circ}\text{C}$ . Add to this increased weight per 100 grams of air-dry soil the weight of hygroscopic water contained in 100 grams of the air-dry soil. This will give the total amount of water taken from the air by 100 grams of water-free soil.

Determine the hygroscopic moisture of each soil with a special sample at the time of starting the experiment.

This experiment brings out the fact that dry soils absorb only a very small amount of moisture from the air, even when the air is saturated, thus correcting an opinion which is prevalent but erroneous.

*Experiment No. 9.*

## A STUDY OF THE RATE OF RISE OF CAPILLARY WATER IN SOILS.

Use soils Nos. 1, 2, 3, 4, and 5 in this experiment. Place a cheese-cloth disk in the bottom of each tube (fig. 18) to prevent the escape of soil grains. Use the compacting machine to fill the tubes, allowing the weight to drop twice from the 12-inch mark after each measure of soil. Weigh the filled tubes carefully and place them in the frame with the lower ends standing in about 1 inch of distilled water, which should be maintained at constant level.

As the water rises by capillarity into the soil the tubes will increase in weight. Weigh the tubes carefully each day for one week, noting the daily increase in each tube and also the total increase for each tube for the period.

*Experiment No. 10.*

## TO TEST THE ADHESIVENESS OF SOILS.

In this experiment soils Nos. 1, 2, 3, and 4 will be used. The adhesiveness will be determined by measuring the

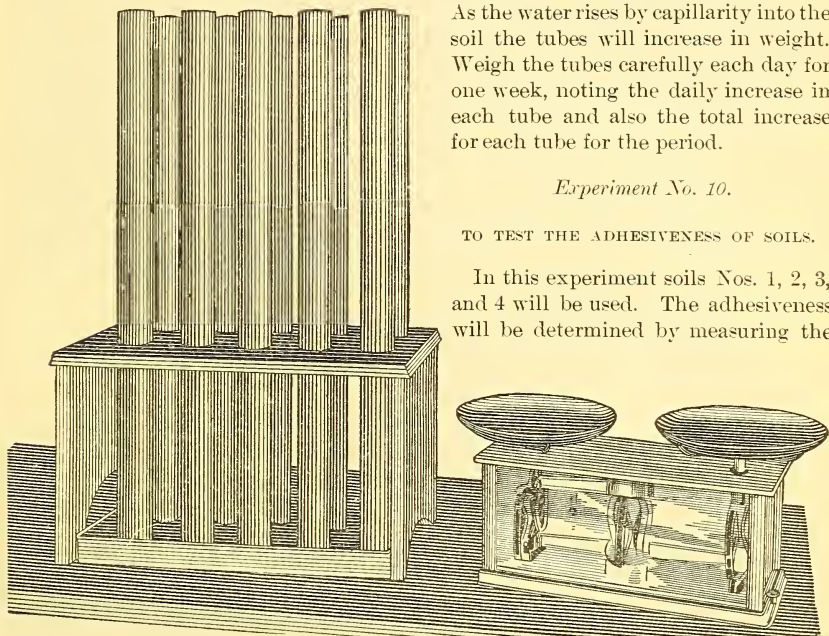


FIG. 18.—Measuring capillarity in soils.

force required to overcome the molecular attraction in a column of moist soil 1 square inch in cross section.

Weigh out roughly 150 grams of soil No. 1 and 180 grams each of Nos. 2, 3, and 4.

Determine the force required to start the empty movable cage (*a*) by running sand from the rubber tube (*b*) into the tin pan (*c*) until the weight is sufficient to cause the cage to move (fig. 19). See to it that the cages are clean and the bearings clean and oiled. The weight of the pan plus the sand it contains represents the force required to overcome the friction of the empty cage, and should be deducted from the total breaking force in each subsequent test of soil.

Empty the weighed sample of soil upon the "mixing board" and add a small quantity of water. Mix soil and water thoroughly by hand working. Enough water should be added to bring the soil to its maximum adhesiveness.

Pack the roll of mud thus formed into the mold, holding the cages together firmly; then with the spatula scrape off the top level with the upper edge of the mold. Attach the pan to the hook at the end of the wire. Pour sand into the pan in a constant stream until the weight is sufficient to separate the cages and break the soil column. Weigh the pan with the sand it contains and deduct therefrom the weight required to overcome the friction of the empty cage. The result represents the adhesive strength of a column of moist soil 1 square inch in cross section.

Care should be exercised to fill the molds as nearly as possible in the same manner in each test.

With this same roll of mud make four tests, using varying amounts of water. The proportion of water may be reduced by adding more dry soil. Test each of the four types of soil in the above manner, using the highest test of each for comparisons of maximum adhesiveness.

*Experiments Nos. 11 and 12.*

MECHANICAL ANALYSIS OF SOILS.

A modification of the method used in the laboratory of the Bureau of Soils of the United States Department of Agriculture. (Pl. XIV, fig. 1.)

Twenty grams of "fine earth" are weighed out and placed in a porcelain or glass mortar. Enough water is added to give the soil the consistency of paste. The mixture is then rubbed with a rubber-tipped pestle.

In rubbing there should be just enough pressure to detach

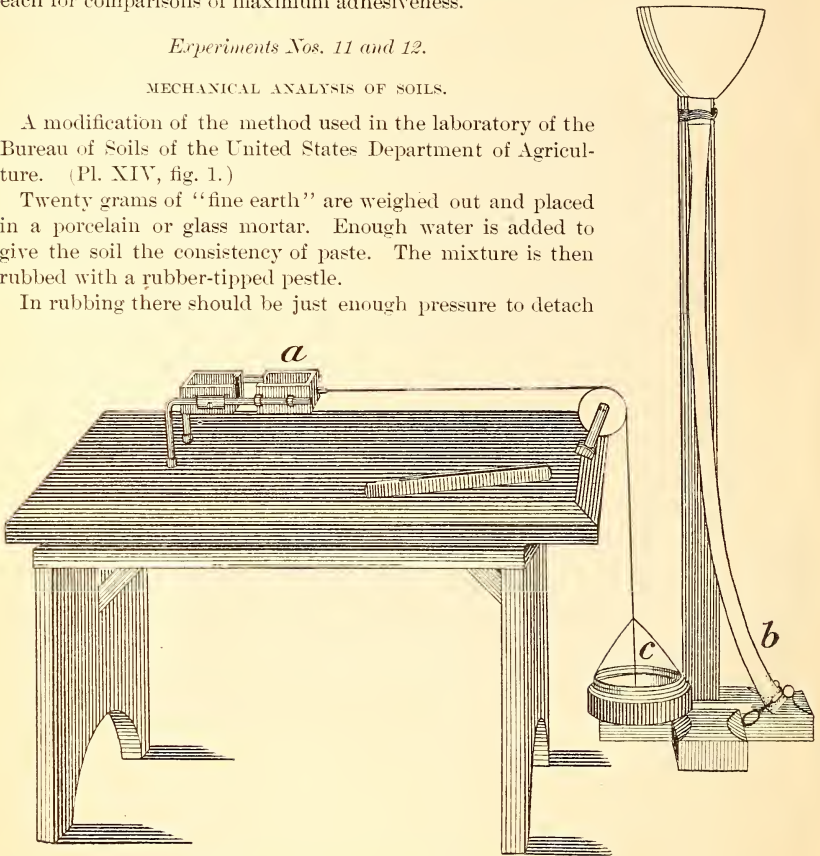


FIG. 19.—Apparatus for testing the adhesiveness of soils.

adhering particles and not enough to break the grains. After five minutes' rubbing more water may be added, and after letting it stand for two or three minutes the turbid liquid is decanted into a beaker, "A." Repeat this pestling and decanting until an examination through the microscope shows the grains to be perfectly clean. When clean the grains show sharp outlines and are transparent, while any adhering finer particles make them round and deeply colored. This pestling may require 15 minutes to an hour or more.

When the material is thoroughly disintegrated, it is transferred from the mortar to a No. 2 or No. 3 beaker, which is then filled with water, stirred and allowed to stand a few minutes, after which it is carefully decanted, leaving the last 20 or 30 cubic centimeters, the liquor being added to the beaker "A." This is repeated until the sand is free from clay, fine silt, and much of the silt. The sand should be tested with the microscope. All particles smaller than 0.05 millimeter are silt or fine silt

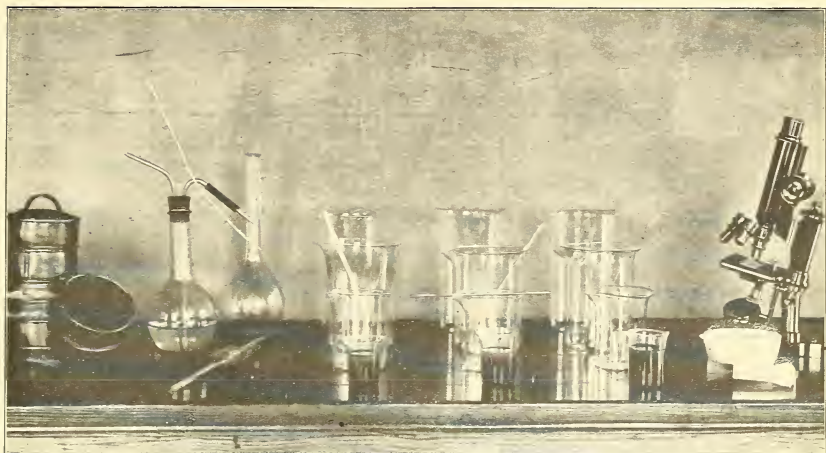


FIG. 1 —OHIO STATE UNIVERSITY—MECHANICAL ANALYSIS OF SOIL.

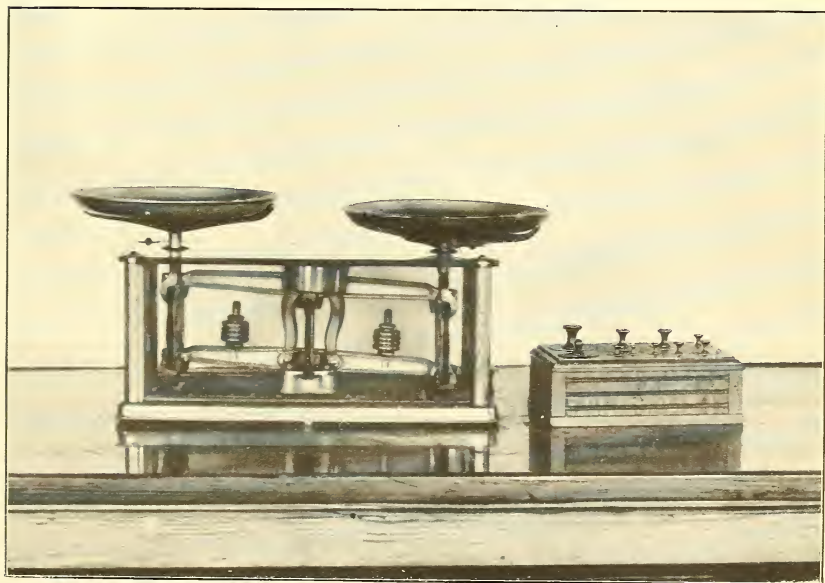


FIG. 2.—OHIO STATE UNIVERSITY—TORSION BALANCE USED IN SOIL PHYSICS LABORATORY.



and should be removed by further decantation. The sediment in the bottom of beaker "A" should also be tested. If it contains particles larger than 0.05 millimeter, the washing or decantation was too rapid. In this case a recovery must be made.

The sand is transferred from the beaker to a porcelain dish and dried. It is then ignited to destroy organic matter, after which it is sifted through a nest of sieves of 1, 0.5, 0.25 and 0.1 millimeter, respectively, that going through the finer sieve being known as very fine sand. These five separations are weighed together before the sifting and separately after sifting.

The amount of silt, fine silt, and clay which was washed away from the sand may be obtained approximately by subtracting the total weight of sand, moisture, and organic matter from the earth taken (20 grams).

Considerable time and skill is required to make the separation of silt, fine silt, and clay. It will not be attempted in this experiment.

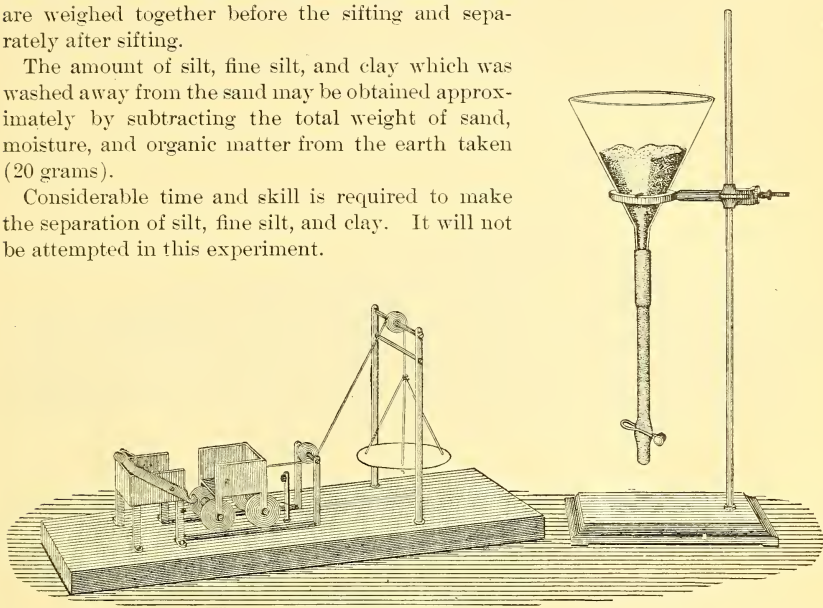


FIG. 20.—Card's apparatus for testing the adhesiveness of soils.

The following are the sizes into which the soil particles are separated:

- No. 1. Gravel, 2-1 millimeters.
- No. 2. Coarse sand, 1-0.5 millimeter.
- No. 3. Medium sand, 0.5-0.25 millimeter.
- No. 4. Fine sand, 0.25-0.1 millimeter.
- No. 5. Very fine sand, 0.1-0.05 millimeter.
- No. 6. Silt, 0.05-0.01 millimeter.
- No. 7. Fine silt, 0.01-0.005 millimeter.
- No. 8. Clay, 0.005-0.0001 millimeter.

Students are required to keep a careful record of each experiment, and at the end of the term to present plates showing their results, and also illustrations of apparatus used, together with description of the method employed.

#### EXHIBIT No. 8.

#### DETAILED SCHEDULE OF LABORATORY WORK.

##### *Advanced course in soils.*

*September 18 and 19.*—Collected samples of soil from fallow, alfalfa, and corn ground to determine moisture content of first and second foot, using sampling tubes and other apparatus, as illustrated in fig. 21.

*September 25 and 26.*—Collected samples of surface foot of muck, first bottom and second bottom soil, for determination of weight per cubic foot of soil under field conditions, using large tube, as illustrated in fig. 21.

*October 2 and 3.*—Discussion of results as obtained in the above experiments with special reference to the methods of expressing amounts of water in the soil; that is, per cent fresh weight, per cent dry weight, amount of water per cubic foot, and surface inches water.

*October 9, 10, 16, 17, 23, 24, 30, and 31.*—Mechanical analysis of two samples of soil—a sand and a clay—by the Osborne beaker method, as modified and used by the Bureau of Soils and described in Bulletin No. 4 of the Bureau, pages 8–13.

*November 6, 7, 13, and 14.*—Separation of “silt,” “fine silt,” and “clay” by the centrifugal method as used in the Bureau of Soils.

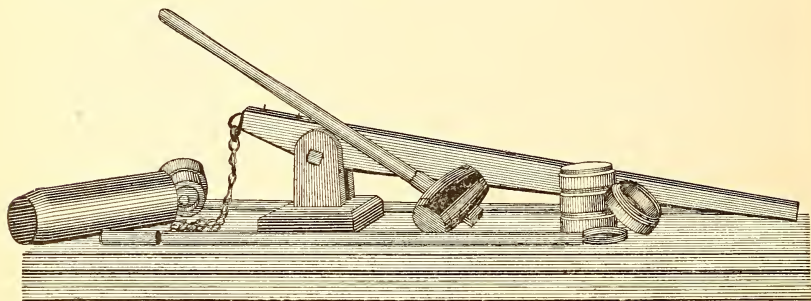


FIG. 21.—Apparatus for taking soil samples.

*November 20, 21, 27, 28, and December 4, 5, 11, and 12.*—Determination of moisture, soluble salts, and temperature of soils by the electrical method, as described and used by the Bureau of Soils.

#### EXHIBIT No. 9.

#### EXAMINATION IN ELEMENTARY COURSE IN FARM CROPS.

The following list of examination questions will serve to indicate the scope of the work covered in the course:

1. Name and explain the reasons for crop rotation.
2. Explain three methods of crop improvement.
3. Give the following statistics on corn and oats for the United States during the last decade: (a) Average annual acreage; (b) average annual yield; (c) average annual yield per acre; (d) average value per acre.
4. Name the eight leading States in the production of each of the following crops: Corn, oats, and barley.
5. Describe structure and give chemical composition of a grain of wheat.
6. Name the types of Indian corn and give the distinguishing characteristics of each.
7. Give the chemical composition of corn.
8. Give general directions as to depth of planting, time of planting, and thickness of planting corn.
9. State the reasons for shallow cultivation of corn.
10. Discuss the following: Time of sowing, depth of sowing, and amount of wheat to sow per acre.
11. What points should be considered in distinguishing between varieties of wheat?
12. Discuss briefly the cost and methods of shipping grain from the farms of the Northwest to the Atlantic seaboard.
13. State the conditions of climate, soil, and seed bed best adapted for oats.

14. Discuss depth of sowing, time of sowing, and amount of oats to sow per acre.
15. Name the regions of greatest production of rye and barley in the United States.
16. Give briefly the history of the cultivation of grasses and clovers.
17. Give common and scientific name of six grasses that are grown in Ohio.
- 18 and 19. Under the following heads discuss common red clover, crimson clover, alsike clover, alfalfa: (a) Scientific name; (b) value for pasturage and hay; (c) climate and soil conditions favorable.
- 20 and 21. Under the following heads discuss Indian corn as a silage crop: (a) Total yield of digestible nutrients as compared with other crops; (b) varieties best adapted; (c) thickness of planting; (d) proper stage of maturity for harvesting.
22. Give directions for growing sugar beets.

EXHIBIT No. 10.

LIST OF LABORATORY OR FIELD PRACTICUMS IN ELEMENTARY COURSE IN  
FARM CROPS.

## Practicum No. 1.

Eight varieties of corn are grown on the university farm annually for instructional purposes. Students are given this work in the fall term of necessity. Each student is provided with the accompanying score card and asked to judge only the stalks in this exercise.

## Practicum No. 2.

The ears, husked from the variety plats, are brought to the laboratory, where a few of the best are selected and the students are asked to score them carefully, according to the card standards as indicated in the following form:

*Students' score card.*

## DENT CORN.

[illegible]

## Students' score card—Continued.

## DENT CORN—Continued.

Scale of points.	Standard.	1	2	3	4	5	6	7	8	9	10	11	12
		Students.	Corrected.	Students.	Corrected.	Students.	Corrected.	Students.	Corrected.	Students.	Corrected.	Students.	Corrected.
EARS—continued.													
Per cent of grain to ear, 85 per cent. Estimated, —, actual, —	10												
Length—10 inches in southern and central, and 9 inches in northern Ohio	10												
Circumference, at two-fifths the length, measuring from base, 7-7½ inches in southern and central, and 6½-7 inches in northern Ohio	8												
Juncture of cob with stalk, ¾ inch in diameter, giving sufficient support for ear without causing inconvenience in breaking	6												
Total													

## NAME OF VARIETY.

## NAME OF VARIETY—continued.

1. ....	7. ....
2. ....	8. ....
3. ....	9. ....
4. ....	10. ....
5. ....	11. ....
6. ....	12. ....

Student: —, —.

Date: —, —, —.

## Practicum No. 3.

The selected ears are shelled, weighed, and the figures arranged according to the following outline, which is handed them:

Variety.	Weight ear.	Weight shelled corn.	Per cent shelled corn.	Pounds shelled corn in 1 bushel ears (68 pounds).	Pounds ears in 1 bushel shelled corn.
No. 2					
No. 4					
No. 5					
No. 6					
No. 7					
No. 8					

Remarks: —, —.

## Practicum No. 4.

## A STUDY OF THIRTY-NINE VARIETIES OF WINTER WHEAT—CLASSIFICATION.

## A. Bearded:

(a) Glumes white.

(a') Berry red.

1. Length of straw less than 3 feet 6 inches.
2. Length of straw more than 3 feet 6 inches.

(b') Berry white.

3. Length of straw less than 3 feet 6 inches.
4. Length of straw more than 3 feet 6 inches.

## A. Bearded—Continued.

(b) Glumes bronze.

(a') Berry red.

5. Length of straw less than 3 feet 6 inches.

6. Length of straw more than 3 feet 6 inches.

(b') Berry white.

7. Length of straw less than 3 feet 6 inches.

8. Length of straw more than 3 feet 6 inches.

## B. Beardless:

(a) Glumes white.

(a') Berry red.

9. Length of straw less than 3 feet 6 inches.

10. Length of straw more than 3 feet 6 inches.

(b') Berry white.

11. Length of straw less than 3 feet 6 inches.

12. Length of straw more than 3 feet 6 inches.

(b) Glumes bronze.

(a') Berry red.

13. Length of straw less than 3 feet 6 inches.

14. Length of straw more than 3 feet 6 inches.

(b') Berry white.

15. Length of straw less than 3 feet 6 inches.

16. Length of straw more than 3 feet 6 inches

Each student is required to hand in a written report of this work.

## Practicum No. 5.

About May 1 each year the class spends one period making notes on the condition of 15 to 20 varieties of grasses and clovers in the grass garden for use later in the term when they come to study the varieties more fully.

## Practicum No. 6.

The "Howe Grain Tester" is used in testing the purity and weight per bushel of wheat, oats, etc.

## Practicums Nos. 7, 8, 9, and 10.

About four periods at the close of the term are given to the study of 15 to 20 varieties of grasses, clovers, and forage plants. Students use the dried specimens in the laboratory as well as the growing plants in the "grass garden." The following outline is given each student, who is required to present an essay on the subject at the end of the term:

## DESCRIPTION OF GRASSES AND FORAGE PLANTS.

Describe the following plants from the bundles given and state use, value, and climatic range and adaptation to soil, and give briefly the results obtained with these plants at experiment stations and elsewhere.

The following books may be used for reference, while below will be given references under each variety to results at experiment stations:

Vasey's Agricultural Grasses of the United States; Beal's Grasses of North America; Hackel's True Grasses; Handbook of Experiment Station Work; Grasses of Tennessee, Part II; Grasses and Clovers, Field Roots, Forage and Fodder Plants, by Professor Shaw; Reports of Kansas State Board of Agriculture, 1895 and 1900; Permanent and Temporary Pastures, Sutton; Forage Crops other than Grasses, Shaw; Bulletins of the Division of Agrostology:

1. *Poa pratensis*, L., Kentucky Blue Grass, Bulletins 5 and 15, Illinois Station; Bulletin 20, Mississippi Station.

2. *Agrostis vulgaris*, L., Redtop, Bulletin 15, Illinois Station; Bulletin 20, Mississippi Station.
3. *Phleum pratense*.
4. *Alopecurus pratensis*, L., Meadow Foxtail.
5. *Dactylis glomerata*, L., Orchard Grass, Bulletins 5 and 15, Illinois Station; Bulletin 20, Mississippi Station.
6. *Festuca elatior*.
7. *Festuca pratensis*, Huds., Meadow Fescue, Bulletins 5 and 15, Illinois Station.
8. *Lolium perenne*, L., Perennial Rye Grass, Bulletin 12, Colorado Station; Bulletin 15, Illinois Station; Bulletin 20, Mississippi Station.
9. *Avena elatior*, L., Tall Meadow Oat Grass, Bulletin 15, Illinois Station; Annual Report 1889, Mississippi Station.
10. *Anthoxanthum odoratum*.
11. *Medicago sativa*, L., Alfalfa, Bulletin 2, Colorado Station; Bulletin 15, Illinois Station; Bulletin 20, Mississippi Station; U. S. Department of Agriculture Bulletin 31; Kansas Report, 1895.
12. *Trifolium pratense*.
13. *Trifolium incarnatum*, Crimson or Scarlet Clover, Bulletin 16, Delaware Station; Report 89, Maryland Station; Annual Report 1889, Mississippi Station; Bulletin 44, Virginia Station.
14. *Trifolium hybridum*, Alsike Clover, Report 89, Maryland Station; Annual Report 1889, Mississippi Station; Bulletin 15, Illinois Station.
15. *Trifolium repens*.

## THE AGRICULTURAL INSTITUTE OF THE UNIVERSITY OF GÖTTINGEN.

By F. W. WOLL,

*Assistant Professor of Agricultural Chemistry, University of Wisconsin.*

This institution is one of the oldest and foremost of its kind in Germany. It is perhaps better known among American experiment station and college men than any other foreign agricultural institution, on account of the high character of investigational work which has been conducted there during the last half century, and because of the many Americans who have studied in Göttingen during this time.

### HISTORY.

Lectures on agriculture have been delivered at Göttingen University since 1770, when J. Beckmann was appointed regular professor of agriculture in the university. He lectured on the subject of agriculture every summer until his death in 1811, and also founded an agricultural-botanical garden to supply instructional material for his lectures, in which all German plants of interest agriculturally were to be grown. It is characteristic that the object of the lectures delivered was not to educate intending farmers, but "to give an insight in farm operations to students who, later on in public service, would be called upon to represent economic interests."

With some interruptions, the lectures were continued until 1852. In that year a special agricultural course of instruction was arranged

for at the university, through the efforts of the political economist, Professor Hanssen, of Göttingen University. The course was planned to last four semesters and was placed under the immediate charge of an agricultural faculty composed of four professors, among whom were Wöhler, the famous chemist, and Gripenkerl, who until his death in 1900 filled the chair of agriculture in the university. The plan of study of the new course was comprehensive. Besides the various fundamental natural sciences, it included agricultural chemistry, veterinary science, meteorology, agronomy, farm management, forestry, political science, and rural law. The theoretical studies were to be supplemented by agricultural excursions to estates in the vicinity of Göttingen: special arrangements were made by which the large Government estate, Weende (an old monastery farm, situated about a mile north of Göttingen), could be visited at any time for instructional purposes, and agricultural experiments could also be made on the land belonging to the estate.

The new course started under favorable auspices and received an impetus through the establishment of the Weende Experiment Station in 1857 by the Royal Agricultural Society of Hanover. One object in establishing the experiment station was to supplement the agricultural instruction at the university by demonstrations, "just as if it were an organic part of the same." In 1857 the official name of the course was changed to the Royal Agricultural Academy of Göttingen-Weende, so as to give definite expression to the close connection between the theoretical instruction offered at the university and the practical work at the model Government farm, Weende. The attendance at the academy gradually increased from only four students in 1851 to over forty in the beginning of the sixties. About this time the number of students that came to receive agricultural instruction began to grow smaller, and there was a steady decrease during the following years, until in 1871-72 scarcely more than a dozen attended the academy. The cause of the decreasing attendance during the last years of this period was not difficult to understand in view of the fact that the Agricultural Institute of Halle University, which was established in 1863, showed a steadily increasing attendance during the same time. The Nestor among agricultural university teachers, Julius Kühn, through whose efforts the Halle Agricultural Institute was established, and to whom more than any other man is due the credit for the splendid growth of agricultural university instruction, both in Germany and in other countries, was the first one to call attention to the fact that an agricultural educational institution that is nothing but a professional school does not supply the facilities for instruction which the times demand. Agricultural science is not merely an aggregation of applied sciences, it has its own special sphere, and in order to live and develop it must have opportunities for verification of prac-

tical experiences and for investigation of its special problems—similar facilities to those long ago accorded, e. g., to medicine. Teachers who lack this opportunity to verify and enlarge the knowledge of the principles of agriculture can not do the best work for their students or for their profession.

A reorganization of the Göttingen Agricultural Academy took place during 1871–1875, to a large extent in accordance with the ideas which J. Kühn advanced and advocated with signal success. The new agricultural institute of the University of Göttingen (Pl. XV) dates from this period. New buildings were erected, laboratories built, the Weende Experiment Station was removed to the agricultural institute (in 1874), and experimental grounds, with garden and greenhouse, were provided for. Later changes made have been comparatively few, and only one of greater importance, viz, the recent establishment of an agricultural-bacteriological institute, the first one of its kind in the world, so far as is known.

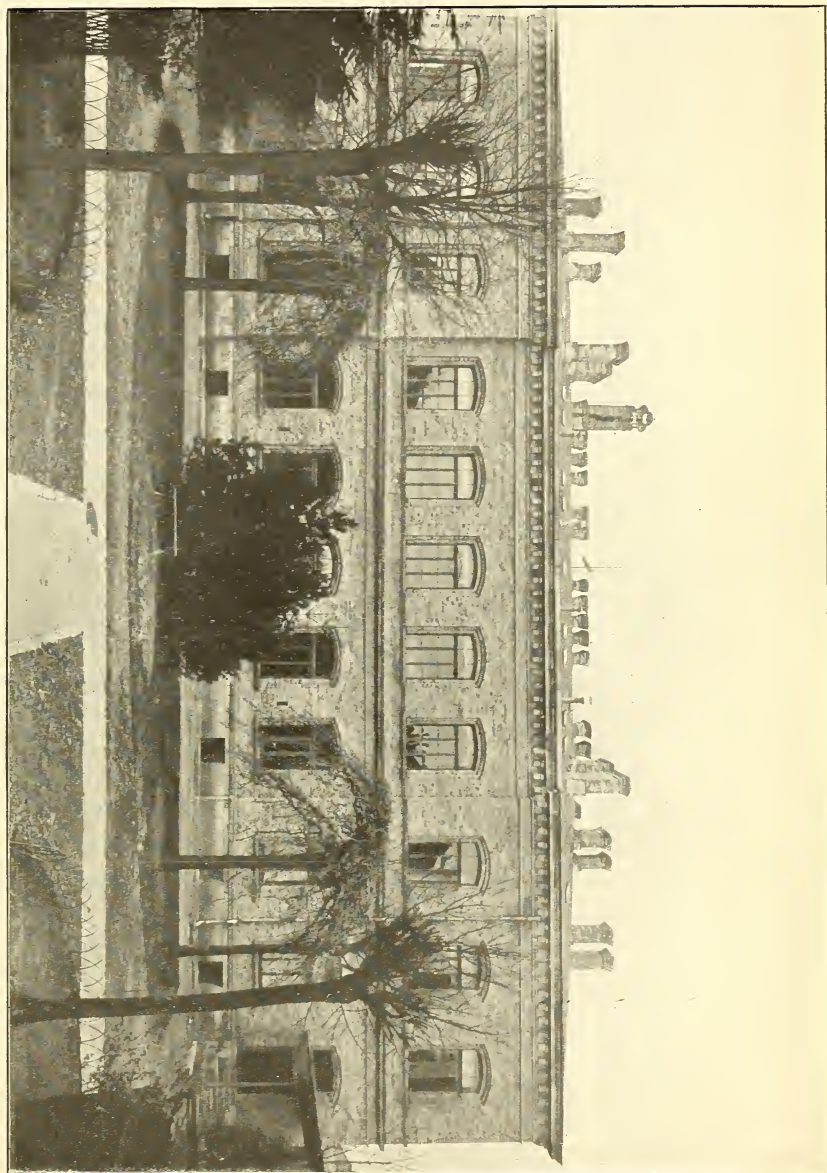
The attendance at the institute during late years, according to the published university catalogue, has been about 30. A number of special students, however, take single lectures or special laboratory work in the institute without being registered as agricultural students, so that the actual number of students attending lectures of professors or working in the laboratories of the institute is somewhat greater than the figure given, but is at any rate small compared with the attendance in agricultural educational institutions of similar standing in this country.

#### PRESENT ORGANIZATION.

The Göttingen Agricultural Institute, as organized at present, is composed of six different departments, viz:

- (1) General agriculture and animal husbandry, in charge of the director of the institute, Prof. W. Fleischmann.
- (2) Agricultural chemical laboratory of the university, Prof. B. Tollens.
- (3) Agricultural experimental grounds, Prof. C. von Seelhorst.
- (4) Animal physiological experiment station, Prof. Franz Lehmann.
- (5) The veterinary institute of the university, Prof. H. J. Esser.
- (6) The agricultural bacteriological institute of the university, Prof. Alfred Koch.

*Assistants in the agricultural institute.*—In one respect there is a marked difference between the Göttingen Agricultural Institute and Station and our American colleges and stations, viz, the abundant help, skilled or otherwise, available for the routine work to be done. The janitors of the European stations do a large amount of semichemical work and render valuable service in many ways that those in America are never called upon to do; the assistants or division heads have in



GÖTTINGEN AGRICULTURAL INSTITUTE—MAIN BUILDING.



general complete charge of all routine work in their respective departments, such as laboratory instruction and the preparation of demonstration material for lectures, thus enabling the director or professor to devote nearly his undivided time and energies to work of a higher grade and to his own studies. The following statement gives the number of assistants and janitors or unskilled laborers, in the Göttingen Agricultural Institute during the season of 1901:

Departments.	Assistants.	Janitors or laborers.
Dairy laboratory.....	1	1
Agricultural chemical laboratory.....	1	1
Plant culture station.....	3	<i>a</i> 9
Animal physiological station.....	3	2
Veterinary department.....	1	1
Agricultural bacteriological institute.....	1	1
Total.....	10	<i>b</i> 15

*a* Three in winter.

*b* Nine in winter.

#### REQUIREMENTS FOR ADMISSION.

To be admitted as a student in the agricultural institute, as in all other departments of the university, one must go through the formality of matriculation. Germans are matriculated when they are graduates of a gymnasium (high school) or have a similar preliminary education, while for foreigners a diploma from a recognized college or university is required. Some latitude as to preliminary education required is allowed in admitting agricultural students, and older farmers, as well as others who wish to attend lectures, may be admitted as *Hospitanten* or *Hörer* (special students) almost without regard to previous training. Several years of practical farm work are considered highly desirable, and students are urged to come to the university so equipped, but previous training in this line is not required. A very large proportion of the agricultural students are the sons of more or less well-to-do farmers, who have taken part in the farm work when their school studies allowed it, and who expect to return to the home farm on the successful completion of their university work; others expect to seek positions as foremen on large estates, or as teachers in the lower agricultural schools.

#### COURSE OF STUDY.

There is no rigid course of study offered in the agricultural institute, nor is the duration of the course at all fixed; it is expected that the required studies can be finished in five or six semesters, but it depends on the student himself whether or not he will present himself for examinations after this time. The following studies are required in the agricultural course as arranged at the present: History of agriculture; plant production, horticulture, plant diseases; animal hus-

bandry—breeding, rearing, and feeding of horses, cattle, sheep, swine, and poultry; veterinary science; agricultural physics—drainage, irrigation, surveying, agricultural machinery and apparatus, farm buildings; farm management and farm bookkeeping. In addition to these professional studies the following fundamental sciences are required: Chemistry (general, industrial, agricultural), physics, botany (general, systematic, physiological), bacteria and yeasts, zoology, geology and mineralogy, meteorology, political economy, and rural law. The instruction is imparted by means of lectures, laboratory work, demonstrations, excursions, and seminars.

Owing to the fact that many of the agricultural students have a limited previous training, the lectures offered in the agricultural institute at Göttingen, as in other German institutions of this class, are, as a general rule, quite elementary. It is well for American students intending to study in Europe to bear this in mind, as it will save them from disappointment later on. The information conveyed in a course of lectures which may not cover more than two or three hours a week for a brief German university semester—sixteen to seventeen weeks in winter and twelve to thirteen weeks in summer—must necessarily be general and can present only the main facts of the subject treated. And after all, the knowledge thus conveyed is but a small part of the benefit derived from attending such a course of lectures; of far higher value to the young student must be counted the opportunity of becoming acquainted with a thinker, to note his methods of treatment and presentation, and to catch something of the enthusiasm of a scholar.

#### METHODS OF INSTRUCTION.

The lectures delivered are, whenever possible, illustrated by charts, maps, museum specimens, or simple experiments. In the lectures on plant nutrition, for example, the whole lecture table is generally covered with specimens of minerals, soils, soil constituents, or fertilizers, according to the subject to be treated in the lecture. A synopsis of each lecture, or manifold copies of tables of figures and the like, to which reference will be made in the lecture, are also furnished by some professors. The literature on the subject treated is also generally shown, either at the beginning of the course or as a special topic is reached, and usually sent around the class for inspection, in the same way as the specimens referred to in the lectures. Electric or other kinds of stereopticons are used at times for exhibiting pictures, charts, etc., on a screen, but not to such an extent as in our better-equipped institutions, nor as successfully, so far as my experience goes.

The method of instruction in agronomy adopted at the Göttingen Agricultural Institute is of interest to the student of agriculture because of the rich material for illustration and demonstration at hand and the excellent opportunity which the excursions made to the many large estates in the surrounding country offer for studying different systems of farming under German conditions. The American student will find the work done in this line full of suggestions and directly applicable at least to Eastern conditions. The instruction is carried on by means of lectures, laboratory work, demonstration on the experimental grounds and in the garden, agricultural excursions, and the agricultural seminar. This work is in charge of the director of the agricultural experimental grounds, Prof. C. von Seelhorst, who is also professor of agronomy in the university.

*Lectures and laboratory work.*—The courses of lectures offered in agronomy are, in the winter semester, general plant production (plant life) and breeding of agricultural crops; in the summer semester, culture of special crops, and weeds and plant diseases. The characteristics of the various kinds of grains, roots, tubers, and other agricultural crops are discussed in the special course, specimens of grain in the sheaf, potatoes, seeds, etc., being supplied in each case, and botanical charts and other illustrative material shown. The laboratory instruction is given throughout the year one afternoon in the week. It consists of microscopical and agricultural examinations of concentrated feeding stuffs as to more important adulterations, quality, etc.; further seed tests, and, in the winter semester, studies of plant diseases. Chemical analyses of crops, soils, fertilizers, etc., are made only as required in special investigations, the general methods adopted in the laboratory work being such as the students will be likely to use and can use later on in their work on the farm.

*Demonstrations.*—The demonstrations on the experimental grounds, in the garden and the greenhouse are of special interest and value to the students. They are given once a week (Monday morning from 7 to 8) during the whole year so long as there is anything of interest agriculturally to be seen outside. The writer attended all demonstrations given during the summer semester of 1901, and was pleased to observe the interest which the students evidently took in the demonstrations, as well as agreeably surprised to note the regularity with which the students met at this rather unusual hour, a regularity which was the more surprising as the attendance at lectures, in the summer semester at least, at most German universities is far from regular. The popularity of the professor in charge doubtless contributed to bring about this result, but not more than did the practical nature of the subject and the abundant material for demonstration at hand. In these demonstrations the professor would conduct the class to the

particular part of the grounds which he wished to speak about, and would then explain the experiments in progress and call attention to special points of importance. The next and following weeks a stop would be made at the same plats to note the development of the crop under the different conditions, differentiation of varieties or of crops under different systems of fertilization, etc. The continuity of the demonstrations gave these talks increased value, the eyes of the students became trained to detect minute differences in the color or luxuriance of plants, and they could follow the gradual differentiations in plants from week to week due to different conditions of fertilization or other influences. The effects of a scarcity or an excess of moisture; effects of hail on different crops, and how they gradually recover, or fail to recover, from these effects; estimation of the damage done by hail, weeds, attacks of insect, or fungus diseases; identification of these, their methods of attack and distribution, and how to combat them; estimations of yields of different crops, etc., are some of the almost innumerable subjects which furnish a well-informed teacher material for lectures in the field. The lectures were informal talks, often interrupted by questioning of the students as to their opinions of matters observed or to be observed. The students would jot down in their note books, although not as frequently as desirable, facts or suggestions brought out. Aside from the fact that the demonstrations served as a convenient method of gathering a large amount of direct practical information on farm topics, they were of great value to the students in teaching them to use their eyes and to apply knowledge obtained in other disciplines, and last, but not least, served to create or maintain an interest and enthusiasm for farm matters which perhaps no other method of instruction would be likely to equal.

It might be thought that there could hardly be anything new or interesting to note on grounds but little over 15 acres in area when the demonstrations came as often as once every week, but with the rich material available, which included dozens of different plat experiments with all kinds of farm crops, rotation experiments, fertilizer tests, pot experiments, etc., this was not the case; on the contrary, the hour proved invariably too short to go over only the portion of the grounds planned each time. The arrangement of the German university year is most favorable for observing the larger share of the round of farm operations. The summer semester covers the time from the end of April to the beginning of August, and the winter semester the time from the end of October to the beginning of March. In these two periods nearly the whole growing periods of most farm crops fall, and most of the important farm work, like preparation of the land in the spring; seeding of spring grains; planting of peas, beans, root crops, and potatoes, and cultivation of the same; cutting and curing of hay; cutting, stacking, and harvesting of small grains,

peas, and other crops; securing the second crop of hay; harvesting and storing of root crops and potatoes; preparing and seeding land to winter grains, etc. Thus a full year's attendance at the demonstrations will bring all the main farm operations up for discussion; it will acquaint the students with the best practices in all cases, and will give them a fund of combined practical and theoretical knowledge which can be drawn upon for assistance throughout their lifetime.

*Excursions.*—A fourth method of instruction in agronomy at Göttingen Agricultural Institute is supplied by the agricultural excursions which are made to estates in the vicinity of Göttingen once every week, generally Saturday afternoons, but at times covering one or more days. The professor and students are shown around the premises by the owner, or in his absence, by his foreman, who explains the system of farming followed, the character of soil and manuring in the different fields, and the history of these for a couple of years back as to crops grown and systems of fertilization. Stables, barns, tool sheds, and other farm buildings are also visited, and the owner's experience is ascertained in each case, questions put by the professor or any in the party being as a rule answered in an open, businesslike way. The excursion generally ends with a short social time, when light refreshments are often served, and points not previously touched upon, or more general topics connected with the farm management, are brought up and discussed. The party is apparently heartily welcome at all the places visited, the farmers seeming to consider it an honor to receive their visitors, in spite of the fact that the visit in some cases is a yearly or even a half-yearly affair. The hospitable spirit shown toward the professor and the young men who are about to enter into practical farm work themselves, is strong evidence of the high esteem in which German farmers hold their higher agricultural educational institutions and the men who are intrusted with the instruction of their sons or neighbors' sons in their future profession.

As the excursions are under the charge of the professor of agronomy they are necessarily of greater benefit to students in furnishing information in this line than along the line of animal husbandry, or special dairy husbandry. In the latter subjects there is, in general, less to be learned in a German university, or in Germany on the whole, by an American student, than in almost any other branch of study, so far as the writer's experience goes.

The relations of the Government estate, Weende, to the agricultural institute are somewhat different from those of the other estates visited, in so far as the renter is under contract to give agricultural students occasional talks on the work in progress on the estate, and to allow inspection of the estate by the students at any time. The fact that the present renter of the estate, Oekonomierat Beseler, is one of the prominent grain growers of Germany, who, besides being the originator of

a number of improved strains of small grains, especially wheat and oats, is a progressive farmer and an excellent instructor, makes the excursions to Weende of the highest value to the agricultural students. The Weende estate has a total area of 672 acres, of which about 480 acres of fields and meadows lie in the alluvial or diluvial soil of the Leine Valley, and the rest is keuper (pœcilitic) soil. To the Weende estate belongs also the Deppoldshausen branch farm, situated on the Göttingen forest plateau, about 1,000 feet high, and 3 miles distant from Weende. This farm lies in the shell-lime formation, and has a thin clay soil calling for methods of farming entirely different from those of the valley farms; it includes an area of 360 acres of cultivated land and 77 acres of pastures. The system of farming followed on estates in the vicinity of Göttingen is mostly grain raising and sugar-beet culture, but there are also a number of large dairy farms that are visited at intervals.

*Seminar.*—The fifth branch of the instruction in plant production in Göttingen is the agricultural seminar. This is held in conjunction with the agricultural excursions, and meets once a week from 8 to 9.30 in the evening (6 to 7.30 in the winter), the professor of agronomy conducting the seminar. One of the students, acting as reporter on the agricultural excursion, prepares a paper on the estate visited, which is read at the seminar. In this a full account is given of what has been seen or learned about the place visited, and criticisms are offered as to farming methods, etc. The discussion following the paper brings out important points that were not considered in the paper, and enlarges upon such not sufficiently elucidated. The business side of the farm operations, the economy of systems of fertilization, the statics of fertilizing ingredients in the soil, system of crop rotation adopted, and special conditions of soil or markets under which the farmer works are among the subjects likely to come up for discussion each time. The regular attendance of the students at the seminar, and the lively discussions which generally arise as to methods of farm practice or principles underlying these, testify to the interest which the students take in this work and the benefit which they derive from taking part in the seminar.

#### FACILITIES FOR INSTRUCTION.

The facilities for work in the various departments are in general up to the requirements of modern educational institutions, even according to the standards common in this country, where, as a rule, buildings and equipment have been provided for the special purpose in view, and are not, as is often the case abroad, the adapted inheritance of earlier times. An American student will most likely be surprised, however, to note the small scale on which the equipment is arranged at Göttingen, as at nearly all other German agricultural colleges.

The dairy and bacteriological laboratory of Professor Fleischmann, whose name is identified with the development of dairy science in all its phases from its beginning until the present time, consists of two rooms, one about 24 by 40 feet and the other 24 by 14 feet, with accommodations for less than half a dozen students. The agricultural chemical laboratory (Professor Tollens) consists of two rooms, one for qualitative and quantitative analysis, with accommodations for 36 students, and one for advanced or thesis work, for 10 students. The general auditorium or lecture room of the agricultural institute has a seating capacity of about 36, and is never crowded—less than ever later in the semester, owing to the German system of non-compulsory attendance.

For purposes of instruction and demonstration in agronomy use is made of the experimental grounds, greenhouse, and other equipment of the plant-culture experiment station. The experimental grounds have a total area of about 15 acres, and adjoin the agricultural institute on the north (Pl. XVI, figs. 1 and 2). Experimental work on this land was begun by Professor Drechsler in the beginning of the seventies, and has included trials of systems of rotations, variety tests

of farm crops, fertilizer experiments, and improvement of cereals and other crops through continued selection. The diagram herewith given shows the divisions of the experimental grounds (fig. 22). The crops grown on these in 1901 were as follows:

*Field A.*—Göttinger rye.

*Field B I.*—Square-head wheat.

*Field B II.*—Potatoes, 22 varieties. Potash fertilizer experiments.

*Field C.*—Red clover.

*Field D.*—Peas, 2 varieties, and beans. Potash fertilizer experiments.

*Field E.*—Rye, flax, winter wheat, mangel-wurzels, barley, beans, potatoes, spring wheat, oats, sugar beets, and potatoes. Fertilizer experiments.

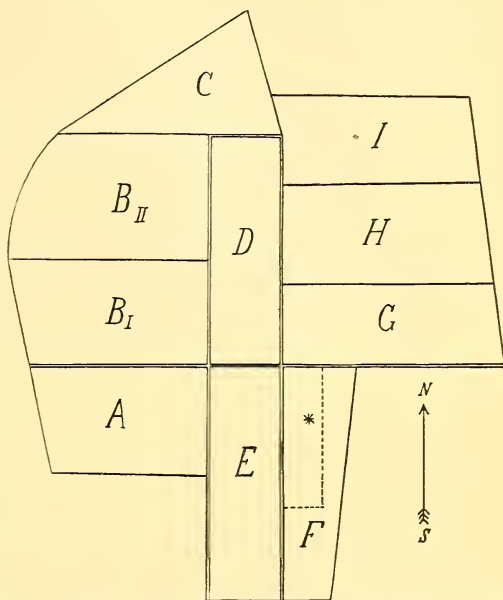


FIG. 22.—Plan of experimental grounds at Göttingen Agricultural Institute.

*Field F.*—Plant breeding experiments with rye, winter wheat, spring wheat, oats, sugar beets, and potatoes. Fertilizer experiments with oats and sugar beets.

*Field F* (south of plant-breeding plats).—Clover, tests of 30 varieties of different origin; spring wheat, 8 varieties; potatoes, breeding experiments with 4 varieties.

*Field F* (east of plant-breeding plats).—Sugar and fodder beets (experiments with different distances of planting); potatoes, 5 varieties; peas, 2 varieties.

*Field G.*—Oats, Göttinger and Beseler's improved, with clover.

*Field II.*—Root crops: Sugar beets, mangel-wurzels. Potash fertilizer experiments.

*Field I.*—Square-head wheat.

In the trial garden small plats are grown of all plants of agricultural importance to northern Germany, the different kinds of grasses and fodder plants, cereals, root crops, small fruits, weeds, etc. Mixtures of grasses and leguminous plants are also grown under different systems of fertilization, to study the effect or to obtain demonstration material for showing the effect of certain fertilizers in favoring the growth of some plants and checking that of others. Similar experiments were also conducted during the season of 1901 in pots in the greenhouse, under liberal or scant supplies of water, in the study of the effect of water supply on the action of different fertilizers or combinations of such.

Pot experiments are conducted in the greenhouse shown in Pl. XVII. The dimensions of the greenhouse are 23 by 49 feet, with a workroom added, 13 by 36 feet. It has accommodations for about 600 pots, which are placed on trucks and in good weather always kept outside. The experiments are conducted according to the plan worked out at the Darmstadt station. The general problem studied during late years is the influence of the water supply on the utilization of different kinds of fertilizers by cereals, grasses, and other farm crops. The laboratory investigations are chiefly supplementary to experiments conducted in the field, garden, or greenhouse, the main work of the assistants being the chemical analysis of materials harvested, soils, fertilizers, etc. A great deal of independent research work has, however, also been conducted in the laboratory, and has from time to time been published in the periodical literature, especially in the *Journal für Landwirtschaft*.

*Library and museum.*—A description of a German agricultural institute would be incomplete without a mention of its library and museum, both of which form all-important parts of the facilities for instruction and research. The library of the Göttingen Agricultural Institute is small, less than 3,000 volumes, but is very complete in German works on agriculture and allied subjects. To an American

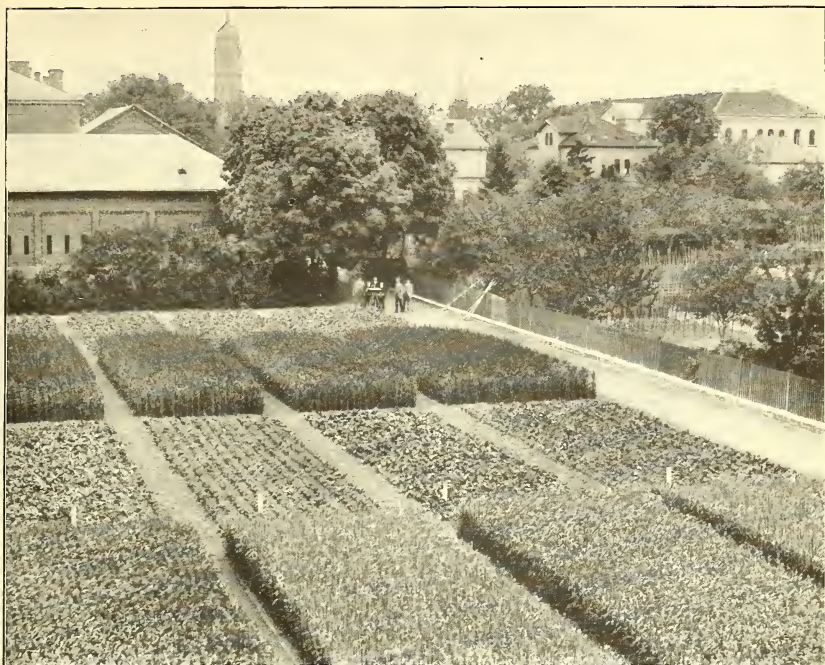
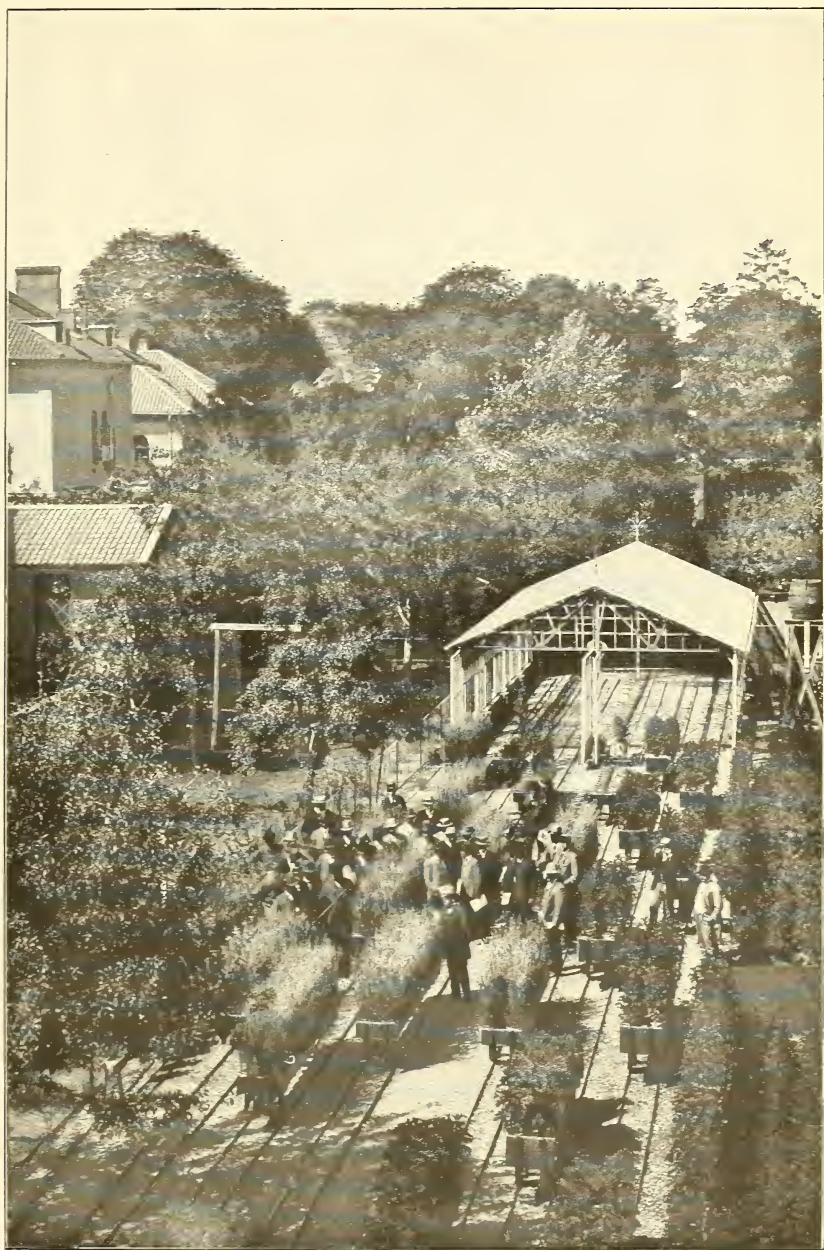


FIG. 1.—GÖTTINGEN AGRICULTURAL INSTITUTE—LOOKING SOUTHEAST.



FIG. 2.—GÖTTINGEN AGRICULTURAL INSTITUTE—LOOKING NORTHEAST FROM INSTITUTE BUILDINGS ACROSS THE EXPERIMENT PLATS.





GÖTTINGEN AGRICULTURAL INSTITUTE—GREENHOUSE.



student the absence of the best foreign (English or American) agricultural literature, in this library as in all other German libraries with which the writer is acquainted, will seem strange. In the laboratories of the institute are found special small, but good, reference libraries, which are accessible at all times and are of great service to students. There is also a reading room, where current numbers of the leading German (and other continental-European) agricultural papers and scientific magazines are kept.

The museum of the Göttingen Agricultural Institute was founded in 1851 by Professor Gripenkerl, and therefore represents half a century's growth. The agricultural faculty have here from year to year deposited collections in their respective lines of instruction and investigation, with the view of making it valuable for instructional purposes rather than of establishing an agricultural museum. The collection of feeding stuffs contains samples of feeds used by Henneberg in his fundamental studies on the nutrition of farm animals, and numerous other specimens in the museum bear testimony of investigations conducted at Göttingen during the latter half of the nineteenth century. The rich collections thus accumulated form invaluable material for demonstration and are constantly utilized by the professors in their lectures.

